Foliar Fungi of Western Trees

A. Funk

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Cover Photo:

Rhabdocline needle cast of Douglas-fir: early spring condition.

Cover Inset:

Ascomata of *Rhabdocline pseudotsugae* and *Phaeocryptopus gaeumannii* on Douglas-fir needle.

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Pacific Forest Research Centre

BC-X-265

1985

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ISSN 0705-3274
ISBN 0-662-14054-0
Cat. No. Fo46-17/265E

Abstract

The descriptions of the foliar fungi of principal western trees and some shrubs are presented. These fungi are all from the Ascomycetes and Deuteromycetes. The diseases induced by the fungi are needle casts, needle blights, leaf spots, tar spots, sooty moulds and mildews. Approximately two hundred species are described. Notes on host range, disease symptoms and taxonomy are included. The descriptions are arranged alphabetically by genus name. Keys for identification appear in the front of the book. An appendix listing the foliar rusts, a glossary, references, host index and general index appears in the back.

Résumé

Nous présentons les descriptions des champignons aux feuillage des arbres de l'ouest. Ces champignons font tous partie des Ascomycètes et des Deuteromycètes. Les maladies provoquées par ces champignons sont les tache des feuilles, rouges, anthracnoses, blancs et fumagines. Inclues aussi sont des notes sur la zone d'hôte, les symtômes de maladies et la taxonomie. Environ 200 espèces de champignon sont inclues. Les descriptions sont arrangées en ordre alphabétique selon le nom du genre du champignon. Au début du livre se trouvent les clefs d'identification; à la fin se trouvent l'appendix des rouille des feuilles, les références littéraires, le lexique, l'index d'hôtes et l'index général.

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Preface

Two descriptive works dealing specifically with the parasitic fungi of western trees have appeared recently. In 1974, W.G. Ziller in his book **Tree Rusts of Western Canada** described all the known rusts affecting western trees. In 1981, I described the ascomycetes and deuteromycetes associated with stem diseases in a book entitled **Parasitic Microfungi of Western Trees**. The present volume deals with the fungi attacking foliage or acting as secondary saprophytes and epiphytes of leaves of the principal western trees and some shrubs (Hosie 1969). The records are based largely on collections held in the herbaria of this research centre and of the Northern Forest Research Centre in Edmonton (see HOST INDEX). These fungi are also ascomycetes and deuteromycetes. Many rusts (Uredinales) also attack foliage, but these were treated by Ziller in the above mentioned work, and are merely listed here under their host genera in the Appendix. This period has also seen the appearance of several excellent handbooks that describe forest diseases in the west (Peterson and Smith 1975; Bega 1978; Holsten *et al.* 1980).

This research centre has produced two notable workers in the foliar fungi: A.K. Parker (1922-1974) who worked on the physiology and taxonomy of *Rhabdocline* and *Dothistroma*, and W.G. Ziller, who in addition to the work on the rusts described many new species and elucidated life cycles. It was my privilege, on occasion, to cooperate with these experts on specific studies, but the foliar fungi were not my area of research. However, my frequent travels and discussions with them enhanced my understanding and appreciation of the many problems and have greatly helped me in the preparation of this book.

The mycologists of the Biosystematics Research Institute, Ottawa, have also contributed immeasurably to this work by identifying many of the species and offering useful comments on them.

Many members of this research centre have helped to make this book possible. Drs. R.S. Hunt and J.C. Hopkins offered much direct assistance and advice in identification. Mrs. D.P. Lowe did proof-reading and checked the references. Mr. J. Wiens arranged and presented the manuscript and artwork. Mr. E.J. Chatelle did much of the photographic work. Members of the Forest Insect and Disease Survey made many of the disease collections. My sincere thanks to all!

Pacific Forest Research Centre
Victoria, B.C. 1984.

Introduction

The foliar fungi form a large and diverse group that has interested taxonomists for nearly two hundred years. Despite the vast amount of knowledge that has accumulated about these fungi, certain problems persist that lead to misunderstanding in diagnosis of disease problems. Only in recent years has extensive life history study combined with close microscopic scrutiny resolved some of these enigmas. For instance, the needle blight of pines, so long attributed to *Lophodermium pinastri*, was shown to be caused largely by a hitherto unrecognized species, *L. seditiosum*, and *L. pinastri* was shown to be a symptomless endophyte (Minter 1981). Certain fungi thought to be primary pathogens were shown to be merely secondary invaders that prevented fruiting of the causal fungus and thereby exerted a degree of natural control (Darker 1964). In the area of taxonomy, the enigma of *Rhabdocline pseudotsugae* was resolved by Parker and Reid (1969) who showed that, instead of a single species, there existed two species with five subspecies, each with a slightly different morphology, life cycle or symptomatology. Even with the recent advances in knowledge, close scrutiny and the practiced eye are necessary for correct identification of many of the foliar fungi.

Life cycles of some foliar fungi, especially the Hypodermataceae and *Rhabdocline*, are strongly regulated to coincide with phenology of the trees and may require up to three years to complete their development. Spore discharge and infection by these fungi is frequently restricted to a specific season. If infection is restricted to newly developing needles then sporulation is timed to coincide with spring budbreak, but successful infection may still be dependent on the right weather conditions occurring in that period. Many other foliar fungi do not appear to be so strongly regulated and could be considered opportunistic or climate-regulated in their sporulation, which often occurs in the same year as the initial infection, or may develop on the cast leaves.

Needle cast diseases are capable of causing tremendous damage, as in the year of writing (1983) when large tracts of interior B.C. forests were absolutely red with various needle diseases. Tree mortality is usually rare, except possibly in the case of young trees that cannot survive repeated defoliation. In older trees, loss of growth increment is the chief result. However, certain foliage diseases may limit planting of exotic trees as in the case of *Dothistroma* blight which will kill *Pinus radiata* in a few years if planted in coastal British Columbia.

The secondary fungi of the needle cast diseases form an interesting group from their physiological aspect. Once thought to be primary parasites, they are now considered to be beneficial by limiting spore production of the parasites. Darker (1964) considered the secondary fungi to be competitors for the food supply in the needles, rather than mycoparasites of the primary fungi. As evidence of the secondary nature, Darker noted that many occurred only in the year during which the primary fungus would have matured. The destruction of the primary invader may be so complete that there is no evidence of their ascocarps, and only the remains of

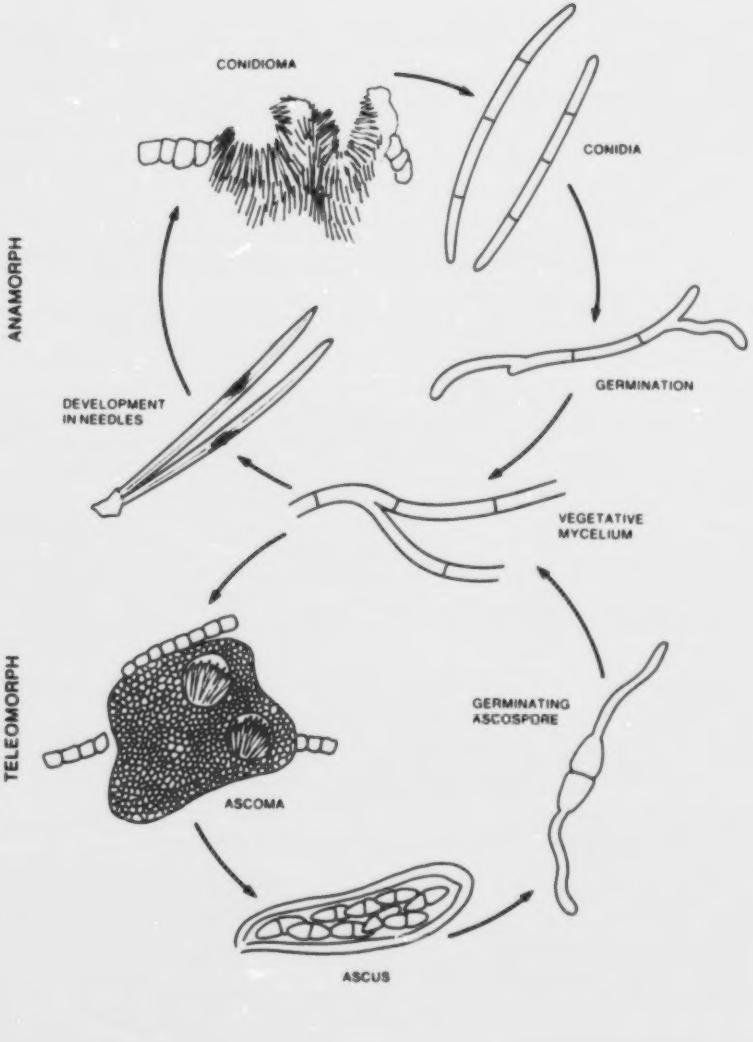

CONIDIOMA
CONIDIA
GERMINATION
VEGETATIVE MYCELIUM
GERMINATING ASCOSPORE
ASCUS
ASCOMA
DEVELOPMENT IN NEEDLES
ANAMORPH
TELEOMORPH

Fig. 1. Life cycle diagram of *Scirrhia pini*, the cause of red-band needle blight of pines.

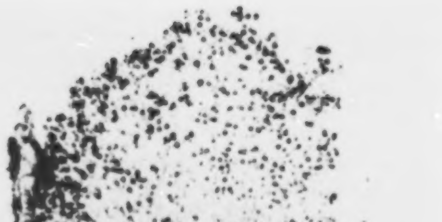


Fig. 2. *Pseudostypella* (*Tremella*) *translucens*, a mycoparasite, attacking the ascoma of *Lophodermium decorum*.

pycnidia give an indication of the original causal fungus. The known and suspected secondary fungi that exert natural control of some needle diseases are listed in Table 5. In contrast to the secondary fungi, *Pseudostypella* (*Tremella*) *translucens* (Gordon) Reid & Minter is a basidiomycetous mycoparasite that attacks the ascomata of *Lophodermium* and *Meloderma* (Fig. 2). Secondary fungi as a distinct group appear to be lacking in the broadleaf diseases.

Foliar symptoms also develop from causes other than fungal infections: climate (frosts, drying winds, drought, etc.), air pollution, mineral deficiencies, root diseases and insect attack. The symptoms of the abiotic diseases usually lack the randomness and the associated fungal fruit bodies present in infectious diseases. The publication by Malhotra and Blauel (1980) is an excellent diagnostic tool in determining the causes of these symptoms.

"Red belt" or winter drying is a climatological cause of needle killing that affects large tracts of coniferous forests. The affected areas are often in the form of narrow, horizontal "belts" on a mountainside. Severe tree mortality has resulted from these occurrences that are associated with warm winds in winter. It is sometimes explained as increased transpiration when the ground is frozen resulting in desiccated needles, but Robins and Susut (1974) present evidence that a rapid drop in temperature following a thaw might explain this sudden damage to conifer foliage.

The work of G.C. Carroll and his co-workers has revealed a group of hitherto unknown fungi that inhabit leaves as symptomless endophytes (Carroll and Carroll 1978). The same workers have also examined the epiphytic fungal flora of leaves, visible only by epifluorescence and scanning electron microscopy (Bernstein and Carroll 1977). These fungi have not been included in the present work, but they represent a very important contribution to our knowledge of the association and interaction of fungi and their host trees, as well as a data base for the effects of air pollutants on phyllosphere fungi (Rossman and Lu 1980).

Many foliar saprophytes increase dramatically as leaves senesce. Although the living leaves all have phylloplane fungi, with senescence the primary saprophytes such as *Cladosporium* predominate, and invade the still living leaves. On dead leaf litter the secondary saprophytes, which include basidiomycetes as well as many microfungi, complete the decomposition (Hudson 1968). This type of successional study is of great interest to the ecologist but is not of immediate concern to the pathologist.

Control of Foliage Diseases

Control of foliage diseases on a forest wide basis is seldom practical or possible. In New Zealand, young stands of Monterey pine are protected by aerial spraying against Dothistroma blight (Red-band disease) (Gibson 1974) and this involves relatively large areas. But in western Canada control practices center chiefly on nurseries, seed orchards, special plantings such as Christmas tree farms, and shelterbelts. The vast stretches of forest that sometimes become infected by foliar parasites may be helped only by natural biological control, such as secondary fungi, and by climatic conditions that hinder sporulation and spread of the fungi.

Chemical control of agricultural foliage diseases has been practiced for more than a hundred years. Since the accidental discovery of the effects of copper sulfate and lime on mildew of grape leaves in 1882, much progress has been made in this field, although the original mixture is still widely used to control fungal diseases under the name of Bordeaux Mixture. Copper in various forms continues to be a useful control chemical but the organic fungicides such as benomyl and daconil are also in wide use. Mercurial fungicides are now largely restricted because of environmental dangers.

Proper timing of fungicidal treatments is very important in controlling foliage diseases. Limited periods of susceptibility occur in some hosts and protective spraying should precede these periods. Spore dispersal in some fungi may also be seasonal or climate-controlled so that host protection must be planned to coincide with the spore showers. In some diseases of conifer needles only the new are susceptible; in others, all ages may be attacked.

Sanitation, i.e., removal of infected fallen leaves, may be a practical form of control in gardens and plantations where the source of inoculum is from fungal fruiting bodies that develop in dead leaves. However, in the case of certain fungi such as *Sirococcus strobilinus* and *Diplodia pinea*, the fungus can also fruit in dead cones or twigs, so that sanitation would require the removal of these parts from the tree.

Phyllosphere fungi, i.e. foliage saprophytes, have also been considered as biological control agents that can limit the severity of infection by foliar parasites. Bier (1965) applied aqueous suspensions of foliar saprophytes to leaves of poplars and obtained decreased infection by the leaf rust *Melampsora*. He also showed that removal of the saprophytes gave increased infection. Etheridge (1965) attempted to control *Dothistroma* blight of pines in East Africa by artificially increasing foliage saprophytes through spraying a nutrient solution on the leaves. A 5% aqueous solution of molasses was used without significant results, but a principle was established that deserves further attention.

Note on Arrangement of Text

All species, regardless of classification, are arranged alphabetically by genus. Taxonomic relationships may be deduced from the keys.

Most species are listed under the name of the teleomorph, i.e., the perfect or sexual state, if it occurs. However, if the anamorph, i.e., the imperfect or asexual state, is more prominent, then it appears under that name. In either case the corresponding state is listed in the general index. Some synonyms are also included in the index.

Keys for identifying the foliar fungi

Foliage diseases are identified chiefly by the fruiting bodies of the fungi found on the affected leaves. These fungi are classified according to their morphology in the following nine groups. A key to the genera of each group follows, but all genera of all groups are arranged alphabetically in the text. Identification of species is by reference to the text. In genera with many species the main features are listed in a table.

ASCOMYCETES

1. A mere film of asci covering the leaf surface .... *Taphrina*
(a single genus)
2. Ascocarp an apothecium, excipular tissue sparse .... *Hemiphacidiaceae*
3. Ascocarp an apothecium, excipular tissue ± developed .... *Discomycetes*
4. Ascocarp hysterioid, ascospores in gelatinous sheath .... *Hypodermataceae*
(Rhytismataceae)
5. Ascocarp a perithecium, asci unitunicate .... *Pyrenomycetes*
6. Ascocarp an ascostroma, asci bitunicate .... *Loculoascomycetes*

DEUTEROMYCETES

7. Conidia produced within a pycnidium .... *Sphaeropsidales*
8. Conidia produced in an acervulus .... *Melanconiales*
9. Conidia produced on conidiophores or hyphae .... *Hyphomycetes*

UREDINALES (RUSTS)

Fruit bodies usually tongue-like or horn-like projections from leaves, orange or white in color. Rusts are listed in an Appendix at the back of the book under host genus.

2. Key to the genera of Hemiphacidiaceae (Korf 1962)

(excipular tissue of apothecia lacking)

1. Ascospores with a distinct constriction near the middle .... 2.
   2. Asci 8-spored, on *Pseudotsuga* .... *Rhabdocline*
   2. Asci 4-spored, on *Tsuga* .... *Fabrella*

1. Ascospores not constricted in the middle .... 3.
3. Asci J-, 4-spored; ascospores 2-celled, pitted; on *Thuja* .... *Didymascella*
3. Asci J-, 8-spored; ascospores clavate .... *Hemiphacidium*
3. Asci J-, 8-spored; ascospores filiform, septate .... *Naemacyclus*
3. Asci J+, 8-spored; ascospores clavate .... *Sarcotrochila*
3. Asci J+, 8-spored; ascospores broadly fusoid .... *Lophophacidium*

3. Key to the genera of Discomycetes

(asci unitunicate, ascocarp an apothecium)

1. Ascospores colored at maturity .... *Stegopezizella*

1. Ascospores hyaline or faintly colored .... 2.
2. Ascospores nonseptate .... 3.
3. Apothecia on a sclerotium .... *Ciborinia*
3. Apothecia on Cupressaceae only .... *Chloroscypha*
3. Apothecia opening by longitudinal split .... *Darkera*, *Lophophacidium*
3. Apothecia opening by teeth .... *Phacidium*
3. Apothecia with lid of epidermis .... *Nothophacidium*
3. Apothecia orange, ascospores sphaerical .... *Pithya*
2. Ascospores 1-septate .... *Diplocarpon*
2. Ascospores multiseptate .... *Gremmeniella*

4. Key to the genera of Hypodermataceae

(ascospores in gelatinous sheath, ascocarp a hysterothecium)

(Figs. 3, 4)

1. Ascocarps linear, often nervisequious, dark brown to black; pycnidia continuous or in broken lines .... 2.
2. Ascospores rod-shaped .... *Virgella*
2. Ascospores bifusiform .... *Isthmiella*
2. Ascospores clavate .... *Lirula*

1. Ascocarps elliptical, concolorous to black; pycnidia scattered or unknown ...... 3.
3. Asci clavate .... 4.
4. Ascospores clavate, ascocarps subcuticular .... *Hypodermella*
4. Ascospores clavate, ascocarps subepidermal .... *Davisomycella*
4. Ascospores clavate, ascocarps subhypodermal .... *Lophodermella*
4. Ascospores elongate-fusiform, 1-septate .... *Elytroderma*
4. Ascospores bifusiform, pycnidia large .... *Bifusella*
3. Asci cylindrical .... 5.
5. Ascospores rod-shaped to fusiform .... *Meloderma*
5. Ascospores filiform, nonseptate .... *Lophodermium*
5. Ascospores filiform, septate .... *Lophomerum*

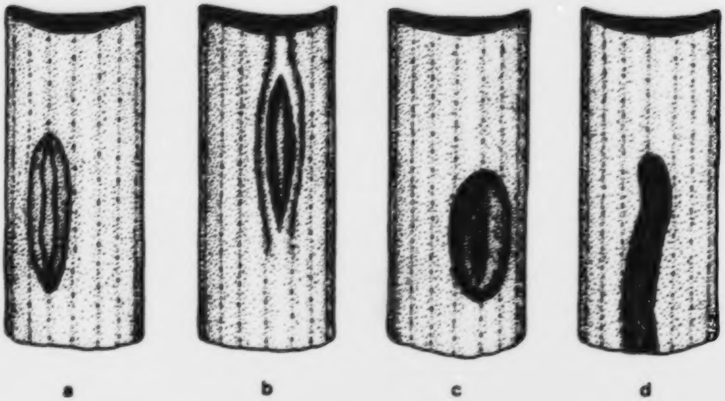


Fig. 3. Ascomata in the Hypodermataceae.
a) concolorous as in *Lophodermella*
b) narrow, black as in *Elytroderma*
c) ellipsoid as in *Lophodermium*
d) nervisequious as in *Lirula*

1. Ascocarps circular to polyhedral .... 6.
    6. Stroma simple .... *Coccomyces*
    6. Stroma polycarpous .... *Rhytisma*

5. Key to the genera of Pyrenomycetes

(asci unitunicate, ascocarp a perithecium)

1. Ascospores hyaline .... 2.
    2. Ascospores ovoid to ellipsoid .... *Phyllactinia, Uncinula*
    2. Ascospores fusiform .... *Gnomonia*
    2. Ascospores filiform .... *Linospora*

1. Ascospores colored .... 3.
    3. Ascospores nonseptate .... *Rosellinia*
    3. Ascospores multiseptate .... 4.
        4. Perithecia in "black mildew," rough .... *Asteridiella*
        4. Perithecia in "black mildew," appendaged .... *Appendiculella*
        4. Perithecia in needles attacked by hypodermataceous fungi .... *Leptosphaeria*

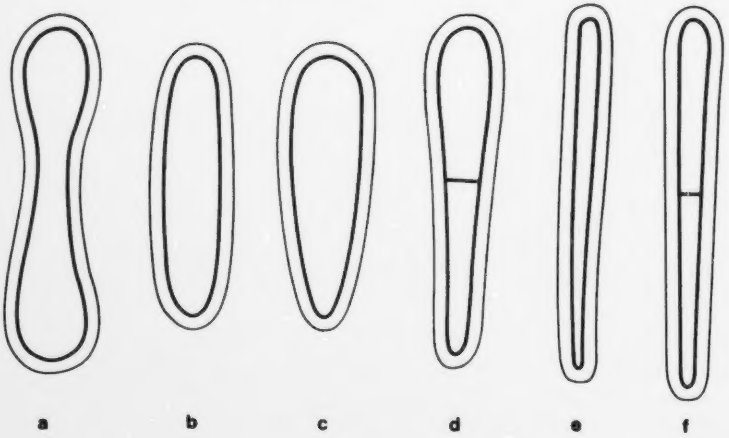


Fig. 4. Ascospore types in the Hypodermataceae (after Darker).
a) bifusiform as in *Bifusella*, *Isthmiella*
b) symmetric as in *Meloderma*, *Virgella*
c) clavate as in *Davisomycella*, *Hypodermella*, *Lirula*, *Lophodermella*
d) clavate-septate as in *Elytroderma*
e) filiform as in *Lophodermium*, *Coccomyces*, *Rhytisma*
f) filiform-septate as in *Lophomerum*

6. Key to the genera of Loculoascomycetes

(asci bitunicate, ascocarps ascostromatic)

1. Ascospores hyaline or faintly colored .... 2.
    2. Ascospores nonseptate .... *Botryosphaeria*
    2. Ascospores 1-septate .... 3.
        3. Ascospores fusoid .... *Delphinella*, *Stomiopeltis*, *Mycosphaerella*
        3. Ascospores cuneate .... *Scirrhia*
        3. Ascospores clavate .... *Phaeocryptopus*
        3. Ascospores ovoid, medianly septate .... *Epipolaeum*
        3. Ascospores ellipsoid, pale green .... *Venturia*
        3. Ascospores ellipsoid, septum in upper third .... *Atopospora*
    2. Ascospores 3-5-septate .... 4.
        4. Ascocarp discoid........ *Cyanodiscus*
        4. Ascocarp sphaeroid .... *Dothiora*
    2. Ascospores muriform .... *Sydowia*

1. Ascospores colored .... 5.
    5. Ascospores 1-septate .... 6.
        6. Thyrothecia on chlorotic spots .... *Thyriopsis*
        6. Thyrothecia in "black mildew" .... *Maurodothina*
        6. Pseudothecia in brown felt blight .... *Herpotrichia*
    5. Ascospores multiseptate .... 7.
        7. Pseudothecia in sooty mould .... *Capnodium, Limacinia*
        7. Pseudothecia in brown felt blight .... *Herpotrichia*

7. Key to the genera of Sphaeropsidales

(conidia produced within a pycnidium)

1. Conidia hyaline .... 2.
    2. Conidia nonseptate .... 3.
        3. Conidia ovoid to ellipsoid .... *Sclerophoma, Phyllosticta, Phyllostictina*
        3. Conidia rectangular, larger than 10 μm .... *Rhizosphaera*
        3. Conidia rod-shaped, plain .... *Leptostroma*
        3. Conidia rod-shaped, appendaged .... *Tiarosporella*
        3. Conidia allantoid .... *Cytospora, Melasmia*
        3. Conidia fusoid, biguttulate .... *Phomopsis* A
        3. Conidia pyriform .... *Leptothyriella*
        3. Conidia filiform, curved .... *Phomopsis* B
    2. Conidia 1-septate .... *Sirococcus*
    2. Conidia 3-septate .... 4.
        4. Conidia broadly fusoid .... *Rhizothyrium*
        4. Conidia falcate .... *Brunchorstia*
        4. Conidia elongate, curved .... *Septoria*
    2. Conidia 3-5-septate, elongate .... *Dothistroma*
    2. Conidia muriform, large .... *Dichomera*

1. Conidia colored .... 5.
    5. Conidia 0-1-septate .... *Diplodia*
    5. Conidia mostly 3-septate .... *Didymosporium, Hendersonia, Lecanosticta, Phaeoseptoria*
    5. Conidia 15-septate .... *Phaeoxyphiella*
    5. Conidia muriform, large .... *Camarosporium, Dichomera*

8. Key to the genera of Melanconiales

(conidia produced in acervuli)

1. Conidia hyaline .... 2.
    2. Conidia nonseptate .... 3.
        3. Conidia oval to rectangular .... *Gloeosporium*
        3. Conidia long, cylindric .... *Colletotrichum*
        3. Conidia rhomboid, in chains .... *Cercoseptoria*
        3. Conidia naviculate .... *Rhabdogloeopsis*

  3. Conidia peanut-shaped, plain .... *Meria*
  3. Conidia peanut-shaped, appendaged .... *Rhabdogloeum*
 2. Conidia 1-septate .... *Marssonina*
 2. Conidia multiseptate .... 4.
  4. Conidia filiform .... *Linodochium*
  4. Conidia insect-like .... *Entomosporium*

1. Conidia colored .... 5.
 5. Conidia 1-septate .... *Pollaccia*
 5. Conidia 3-septate, appendaged .... *Truncatella*
 5. Conidia 4-septate, appendaged .... *Pestalotiopsis*
 5. Conidia 5-septate .... *Seiridium, Leptomelanconium*
 5. Conidia 6-8-septate .... *Cercospora*

9. Key to the genera of Hyphomycetes

(conidia on hyphae or specialized conidiophores)

1. Conidiophores simple .... 2.
 2. Conidia hyaline, nonseptate .... *Hormisciomyces*
 2. Conidia hyaline, in chains .... *Oidium*
 2. Conidia hyaline, complex .... *Cristulariella*
 2. Conidia dark, 1-septate .... *Pirozynskia*
 2. Conidia dark, muriform .... *Epicoccum*

1. Conidiophores sporodochial .... 3.
 3. Conidia hyaline, nonseptate .... *Kabatina*
 3. Conidia hyaline, triradiate .... *Vanterpoolia*
 3. Conidia dark, multiseptate .... *Stigmina*

Descriptions of species

(all species arranged alphabetically by genus)

Apiosporina collinsii (Schw.) Hoehn. Sitzb. K. Akad. Wiss. Wien *119:* 439 (1910).

ANAMORPH: *Cladosporium*

Systemic in twigs, where thick, black, mycelial subicula are formed. Ascostromata black, hypophyllous on a subiculum, gregarious, globose, ostiolate, tapered at the base, 125-250 μm diameter, collapsing when dry. Asci clavate, bitunicate, 40-70 × 9-12 μm. Ascospores pale green to yellowish brown, elliptic-fusoid, 1-septate near the base, 12-15 × 4-6 μm.

Conidiophores covering subiculum early in the season, erect, single or branched, septate, brown, up to 225 μm long and 4 μm wide. Conidia ellipsoid, denticulate, brown, nonseptate, 8-18 × 5-8 μm.

HOST: *Amelanchier alnifolia*

DISEASE: Causes a mild brooming of Saskatoon where it is systemic in the twigs, and a blackening and curling of the leaves.

Apostrasseria lunata (Shear) Nag Raj Can. J. Bot. *61:* 19 (1983).

TELEOMORPH: *Phacidium lunatus* DiCosmo, Nag Raj & Kendrick

Pycnidia stromatic, dark brown, ostiolate, often with a conical neck, immersed, globose to subglobose, 170-500 × 120-300 μm deep, locule convoluted or irregularly divided; wall up to 40 μm thick, of brown *textura angularis.* Conidiogenous cells annellides, ampulliform or lageniform, 4-12 × 2-5 μm. Conidia blastic, hyaline, nonseptate, lunate, apex rounded, base truncate, 5-13 × 2-3 μm, with conical, mucoid, apical appendage.

HOST: *Larix occidentalis*

DISEASE: Found on necrotic primary needles of stored larch seedlings.

Appendiculella pinicola (Dearn.) Pirozynski & Shoemaker Can. J. Bot. *48:* 1321 (1970).

Colonies amphigenous on the needles, dense, smooth black. Mycelium superficial, reticulate, branching; hyphae dark brown, septate, anastomosing, straight to flexuous, 6-10 μm wide, bearing capitate and mucronate hyphopodia.

Ascomata black, globose, appendages larviform, up to 250 μm diameter Ascospores dark brown, thick-walled, ellipsoid, curved, 3-septate, 46-58 × 15-21 μm.

HOST: *Picea sitchensis*

NOTE: Epiphytic on living needles, causing "black mildew."

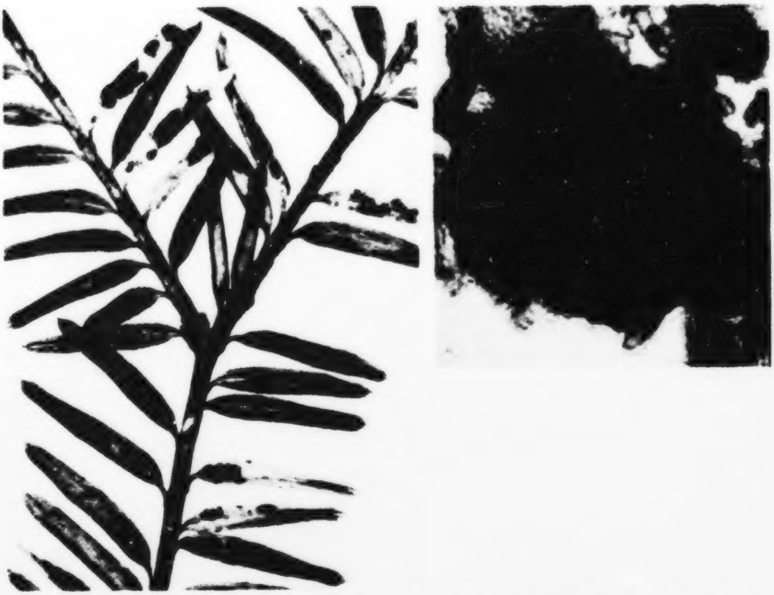


Fig. 5. *Asteridiella pitya.* "Black mildew" on yew leaves. Colony and ascoma.

Asteridiella pitya (Sacc.) Hansf.   Sydowia *10:* 49 (1957).

Colonies amphigenous on the needles, discrete, approximately 2 mm diameter, or confluent, smooth, black. Mycelium superficial, reticulate; hyphae dark brown, thick-walled, flexuous, bearing capitate hyphopodia.

Ascomata globose, roughened by protruding surface cells which are conic, dark brown, up to 300 μm diameter. Ascospores dark brown, thick-walled, ellipsoid, curved, 3-septate, 43-52 × 16-20 μm (Fig. 5).

HOST: *Taxus brevifolia*

NOTE: Epiphytic on living needles, causing "black mildew" characteristic of the largely tropical order Meliolales (Pirozynski and Shoemaker 1970).

Atichia glomerulosa (Ach. ex Mann) Stein   Krypt. Fl. Schlesiens *2:* 356 (1879).

TELEOMORPH: *Seuratia millardetii* (Racib.) Meeker

Stromatic colonies superficial on living or dead bark, irregular, dark brown, hard when dry, swelling and becoming cartilaginous when moistened. Tissue consists of torulose cells in a gelatinous matrix, inner cells subhyaline. Colonies at maturity with subglobose swellings approximately 100 μm diameter, total size rarely exceeding 1 mm (Fig. 6).

HOSTS: *Pseudotsuga menziesii, Abies grandis*

NOTES: A common epiphyte in the wet coastal areas, usually only in the vegetative form. This fungus is common on subtropical vegetation (Meeker 1975).

Atopospora betulina (Fr.) Petrak Ann. Mycol. *23:* 101 (1925).

Stromata black, shiny, pulvinate, subcuticular, 0.3-1.5 mm diameter, 45-85 μm high, multiloculate, pseudoparenchymatous. Locules in a single layer, 60-80 μm diameter, opening by a pore. Asci cylindric, 8-spored, 36-54 × 9-14 μm, bitunicate. Ascospores elliptical, yellowish to greenish, septate in upper third, 10-15 × 4-6 μm (Fig. 7).

HOSTS: *Betula* spp.

DISEASE: Shiny tar spot in green leaves.

NOTE: Stromata form in living leaves but ascospores mature after overwintering.

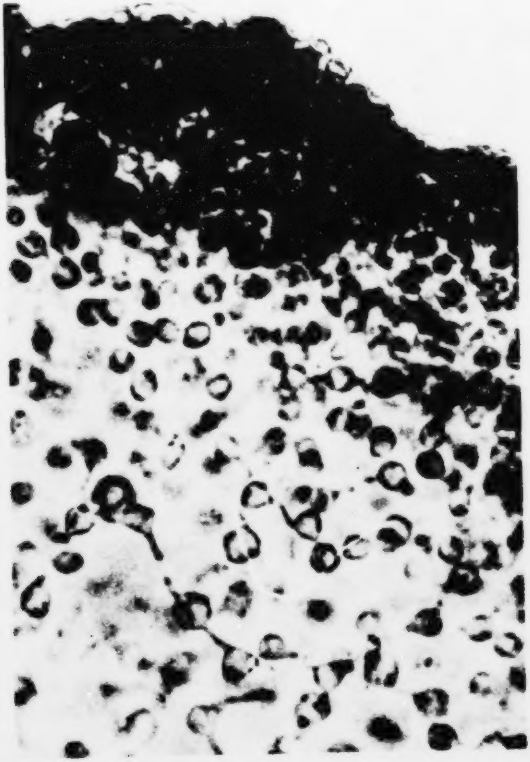


Fig. 6. *Atichia glomerulosa.* Cells of vegetative stroma.

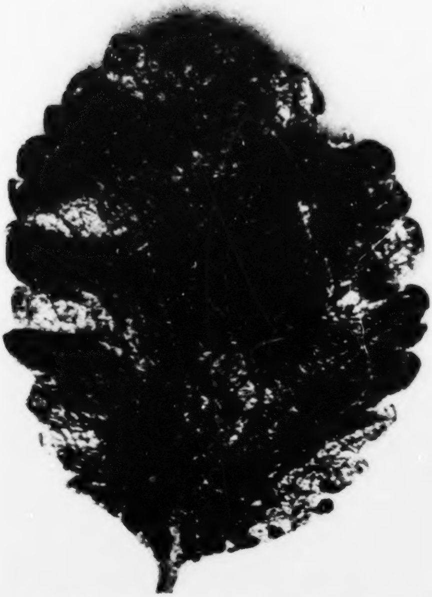


Fig. 7. *Atopospora betulina.* Stromata on birch leaf causing "tar spot."

Bifusella Hoehn. Ann. Mycol. *15:* 318 (1917).

Hysterothecia black, elliptical, subcuticular; hymenium flat, subhymenial layer thin. Asci clavate. Paraphyses absent or tending to disappear at maturity. Ascospores bifusiform or rod-like and tending toward bifusiform (Fig. 4).

Pycnidia large or coalescing into large areas, covered by a thin pseudoparenchymatous layer attached to the cuticle. Spermatia relatively large, rod-shaped.

1) **Bifusella linearis** (Peck) Hoehn. is common on needles of *Pinus monticola* and *P. albicaulis.* Hysterothecia are shiny black, subcuticular, elliptical, 0.4 — 0.9 mm long. Asci are clavate, 130-190 × 19-28 μm. Ascospores are bifusiform, 41-60 × 3-4 μm. Often followed by *Hemiphacidium planum* (q.v.) which inhibits *Bifusella* fruiting.

2) **Bifusella saccata** (Darker) Darker occurs on *Pinus albicaulis* and has hysterothecia black, subcuticular, 4-8 × 0.6-0.9 mm. Asci 160-185 × 27-33 μm, clavate. Ascospores more rod-shaped, 24-36 × 4-6 μm. On dead tips of green needles.

3) **Bifusella pini** (Dearn.) Darker on *Pinus cembroides* var. *monophylla* has large cylindrical ascospores measuring 36-69 × 7-14 μm.

Botryosphaeria abietina (Prill. & Delacr.) Maubl. Bull. Soc. Mycol. Fr. *23:* 169 (1907).

Pseudothecia black, subglobose, subepidermal, immersed in mesophyll, 250-350 µm diam, wall of thick-walled, black pseudoparenchyma, becoming hyaline inwards and thinner walled near the opening, 25-35 µm thick. Asci cylindric-clavate, 8-spored, 100-140 × 16-25 µm, immersed in interthecial tissue (paraphysoids). Ascospores hyaline, nonseptate, ellipsoid, 22-30 × 8-11 µm.

HOST: *Abies grandis*

DISEASE: Needle blight of grand fir. Apparently occurs chiefly on needles of understory branches.

NOTE: Arx and Müller (1954) apparently made the same combination as Maublanc for this fungus and it is their description that is given here.

Botrytis cinerea Pers. Syn. Meth. Fung. 690 (1801).

TELEOMORPH: *Sclerotinia fuckeliana* (de Bary) Fckl.

Conidiophores arising within shoots and leaves, forming a grey weft over them, up to 2 mm long and 15-30 µm wide, with a stipe and open head of branches, smooth, clear brown below, paler near the apex, ends of branches almost hyaline. Conidiogenous cells polyblastic, terminal on the branches or growing out of subterminal cells. Conidia holoblastic, ellipsoid to obovate, colorless to pale brown, with a slight frill or hilum at point of attachment, 6-18 × 4-11 µm. Small, black, irregular sclerotia may also be present on the host or in culture. The ascigerous stage is rarely found (Fig. 8).

HOSTS: Most conifers and many broad-leaved species.

DISEASE: Causes blight or rot (Gray mould) of nursery seedlings and stored planting stock of conifers.

Camarosporium strobilinum Bomm., Rouss. & Sacc. Syll. Fung. *10:* 344 (1892).

Pycnidia dark brown, glabrous, globose, sessile, superficial, 300-500 µm diameter; ostiolate, not beaked; walls of brown *textura globulosa*, grading to hyaline, compressed cells toward interior. Conidia at first clavate, becoming globose, brown with lighter colored basal cells when young, muriform, 21-35 × 17-20 µm exuding in a slime drop. Conidiophores mostly simple annellophores, 15-40 × 2-4 µm (Fig. 9).

HOSTS: *Abies lasiocarpa, Picea glauca*

DISEASE: Parasitic on buds and shoots of subalpine fir and white spruce, causing necrosis and dieback (Shoemaker 1967). Epidemic outbreaks sometimes occur.

Capnodium walteri Sacc. Hedwigia *32:* 58 (1893).

ANAMORPH: *Phaeoxyphiella morototoni* Bat. & Cif.

Colonies composed of an irregular network of loose, brown, repent hyphae. Ascostromata black, ovoid, sessile, ostiolate, nonsetose. Asci bitunicate, 8-spored. Ascospores brown, 3-septate, ovoid, constricted at middle septum.

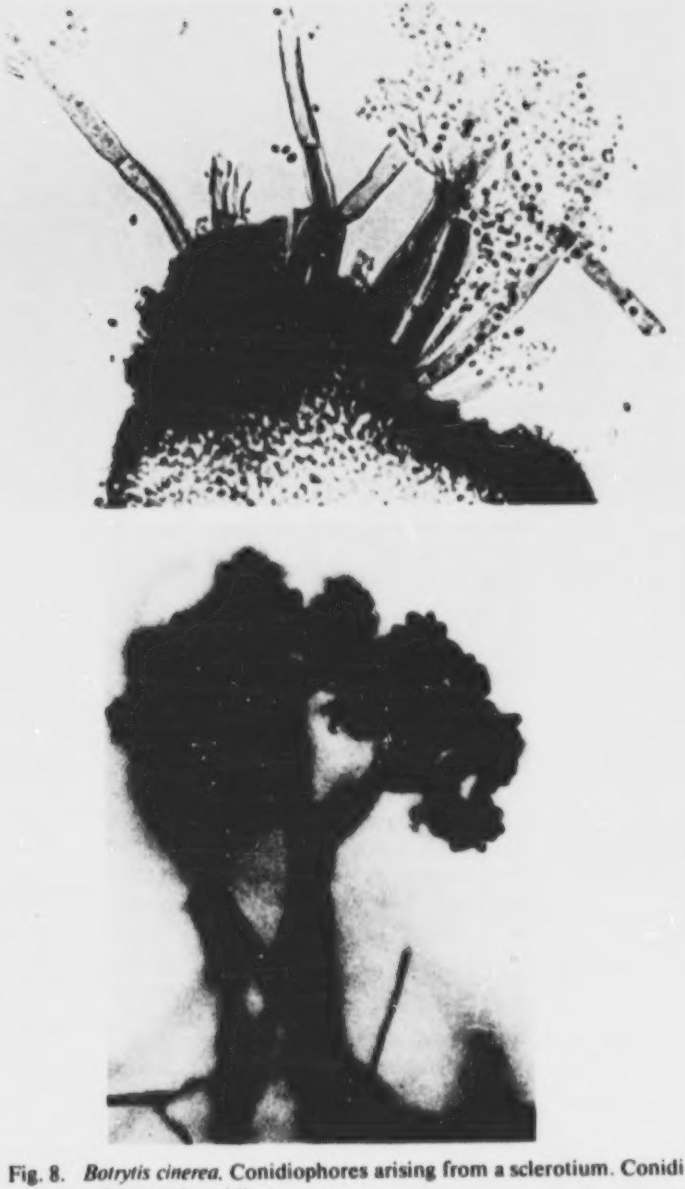


Fig. 8. *Botrytis cinerea.* Conidiophores arising from a sclerotium. Conidiophore and conidia.

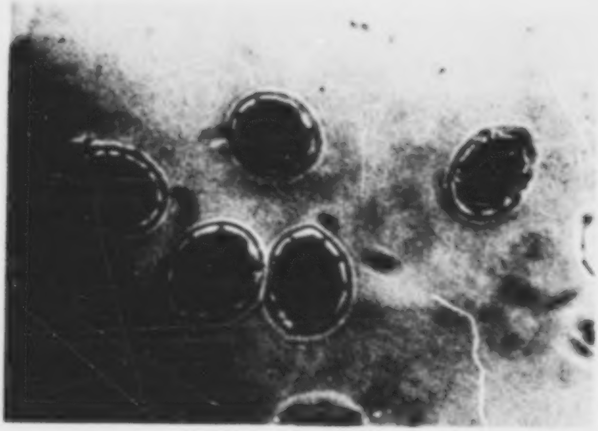


Fig. 9. *Camarosporium strobilinum*. Conidia.

Pycnidia flask-shaped, barely stalked, neck tapered and terminating in an ostiole surrounded by blunt ends of hyphae. Conidia fusoid, straight, reddish brown, acute apex and flat basal scar, 15-septate.

HOST: *Arbutus menziesii*

DISEASE: Sooty mould of arbutus leaves.

NOTE: Associated with infestation of scale insects on the lower surface of the leaves. The mould is nourished by the "honey dew" deposited on them from above (Hughes 1976).

Cenangium acuum Cooke & Peck Grevillea *7*:40 (1878).

SYNONYM: *Mollisia pinastri* Sacc.

Apothecia reddish-brown, circular with an irregularly toothed margin, up to 1 mm diam, hymenium plane, lighter in color than excipulum, erupting through epidermis. Asci clavate with abrupt, stem-like base, 8-spored, 80-100 × 8-10 μm. Ascospores fusoid, nonseptate, hyaline, 12-14 × 3-4 μm. Paraphyses filiform, tips enlarged.

HOST: *Pinus monticola*

NOTE: Probably saprophytic.

Cercospora sequoiae Ell. & Ev. J. Mycol. *3*:13 (1887).

Conidiomata stromatic acervular, black, erumpent, amphigenous. Conidiophores dark, simple, septate, geniculate, with thickened scars, borne in fascicles, slightly roughened, 50-125 × 4-6 μm. Conidia tapered toward the tip, straight or curved, yellowish-brown, 0-8-septate, often constricted at the septa, slightly echinulate, 25-80 × 4-8 μm.

HOSTS: *Juniperus*, *Sequoia*, *Cupressus*

DISEASE: Foliage necrosis of lower branches adjacent to the stem; spreads upward and outward. May kill seedlings or cause mild cankering of stems (Hodges 1962).

Cercosporella alni Dearn. and Barth Mycologia 9: 362 (1917).

Conidia consisting of tufts of filamentous, hyaline appendages, densely fasciculated, often collapsing into a mop-like mass when wet, bound together by a stromatic base. Filaments 250-400 × 5-7 μm, 2-6-septate, cylindrical with obtuse apices. (Fig. 10)

HOST: *Alnus rubra*

DISEASE: Brown leaf blotch and early abscission.

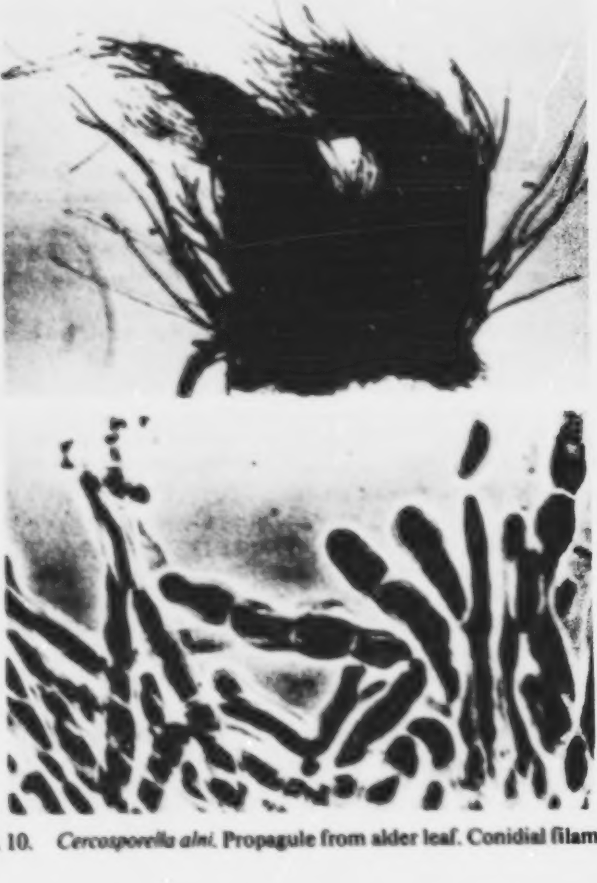


Fig. 10. *Cercosporella alni*. Propagule from alder leaf. Conidial filaments.

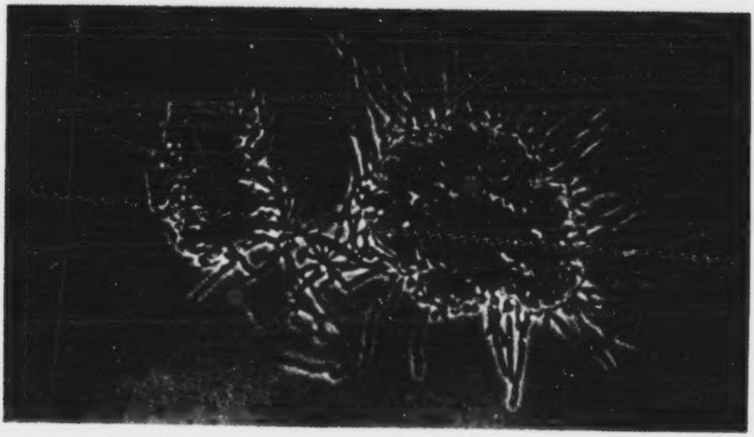


Fig. 10a. *Cercosporella aceris.* Propagules from maple leaf.

NOTES: A species on broadleaf maple is *Cercosporella aceris* Dearn. and Barth. with smaller filaments (100-300 × 5-6 μm) and causing zonate leaf spots (Fig. 10a).

Both species of *Cercosporella* are being revised to a new genus, *Mycopappus* (S.A. Redhead, Can. J. Botany 1985) (in press).

Chloroscypha sabinae (Fckl.) Dennis Kew Bull. 410 (1954).
SYNONYM: *Kriegeria juniperi* (Ellis) Seaver

Apothecia short-stalked, round, black, 0.4-0.5 mm diameter, glabrous. Asci clavate, 8-spored, rounded apex blued by iodine, 150 × 20 μm maximum. Ascospores hyaline, nonseptate, ellipsoid-fusiform, 15-20 × 8-9 μm. Paraphyses branched, thickened at the tips, forming a brown epithecium.
HOSTS: *Juniperus* spp.

Chloroscypha seaveri Seaver Mycologia *23:* 249 (1931).
SYNONYM: *Kriegeria seaveri* (Rehm) Seaver

Apothecia single or in small clusters, short-stipitate, turbinate, greenish black to black, less than 0.5 mm diameter. Asci clavate, 8-spored, 100-135 × 25-30 μm. Ascospores yellowish, granular, 2-seriate, fusoid, nonseptate, 20-30 × 8-10 μm. Paraphyses filiform, forming a brown epithecium where united at the tips.
HOSTS: *Thuja plicata, Chamaecyparis lawsoniana*

Ciborinia foliicola (Cash & Davidson) Whetzel Mycologia *37:* 668 (1945).

Sclerotia surrounding the midribs of overwintering leaves or formed in the blade, 10-20 × 1-1.5 mm.

Apothecia arising singly from the sclerotia, with rhizoidal tufts, stalked, light brown, cupulate to discoid, 2-6 mm diameter; stalks 2-5 mm long. Asci cylindrical, 8-spored, pore staining blue in iodine, 125-150 × 7-9 μm. Ascospores ellipsoid, biguttulate, nonseptate, hyaline, 9-12 × 6-7 μm. Paraphyses slightly clavate, simple, light brown above, 1-2 μm broad.

HOSTS: *Salix*

DISEASE: Black rib of willows. Leaf necrosis is accompanied by formation of light brown zones of discoloration.

NOTES: Another species on *Salix*, ***Ciborinia wisconsinensis*** Batra lacks the rhizoidal tufts and appears to favor the lanceolate-leaved willows; *Ciborinia foliicola* favors the broad-leaved willows (Sutton and Lawrence 1969).

Ciborinia pseudobifrons Whetzel Can. J. Bot. *33:* 583 (1955).

Sclerotia formed in living leaves and remaining after leaf fall, black, oval or elongate, 10-15 × 3-5 mm (Fig. 11).

Apothecia occurring on sclerotia in leaves lying on the ground, stalked, brown, cupulate to discoid, 1-3 mm diameter; stalks up to 12 mm long. Asci slender, clavate, 8-spored, pore staining blue in iodine (J+), 110-130 × 7-9 μm. Ascospores uniseriate, ovoid, hyaline, nonseptate, 7-10 × 3-4 μm. Paraphyses 2 μm wide, slightly enlarged at the tips.

HOST: *Populus tremuloides*

DISEASE: "Inkspot" of leaves.

NOTES: Sclerotia of *C. pseudobifrons* occur mostly on veins and petioles and remain attached, whereas sclerotia of *C. whetzelii* are in the blade of the leaf and drop out in late summer (Baranyay and Hiratsuka 1967).

Ciborinia whetzelii (Seaver) Seaver N. Am. Cup Fungi (Inoperculates) 70 (1951).

Sclerotia formed in living leaves, black, circular to irregular, 2-8 mm diam, usually dropping out in late summer leaving "shotholes" in the leaf.

Apothecia occurring on sclerotia lying on the ground, stalked, brown, cupulate to discoid, 2-10 mm diameter, stalks 5-25 mm long. Asci clavate, 160-180 × 11-12 μm, pore staining blue in iodine. Ascospores uniseriate, ellipsoid, nonseptate, hyaline, 12-15 × 6-9 μm. Paraphyses numerous.

HOSTS: *Populus tremuloides*, *P. balsamifera*

DISEASE: "Inkspot" and "Shothole" of poplars (Fig. 11).

NOTES: Another species on western aspen is ***Ciborinia seaveri*** Groves & Bowerman which has much smaller asci (46-65 × 6-7 μm) and much smaller ascospores (7-10 × 2-4 μm); but sclerotia are similar to *C. whetzelii*. Apparently rare. (Groves and Bowerman 1955).

Coccomyces arbutifolius Sherwood Occ. Papers Farlow Herb. No. *15:* 22 (1980).

Apothecia subepidermal, dark brown, densely gregarious, irregular to elongate, opening irregularly by splitting of the dark covering layer, 0.2-1.0 mm diam. Asci 120-150 × 15-20 μm, clavate, long-stalked, 8-spored. Ascospores

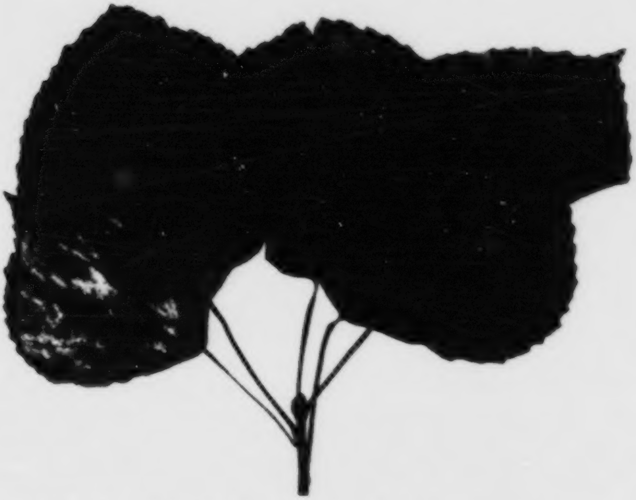


Fig. 11. *Ciborinia whetzelii.* Sclerotia in aspen leaves.

Fig. 12. *Coccomyces arbutifolius.* Leaf spot of *Arbutus.*

hyaline, 75-100 × 2.5 μm, nonseptate, in mucilaginous sheath. Paraphyses filiform, simple or branched, enlarged at the tips. Subhymenium colorless (Fig. 12).

HOST: *Arbutus menziesii*

DISEASE: Leaf spot of arbutus. Discolored spots marked by a faint whitish bloom.

NOTES: ***Coccomyces dentatus*** (Fr.) Sacc. sometimes found on dead leaves of *Arbutus*, has shiny black hexagonal to quadrate apothecia with preformed opening splits; ascospores measure 45-65 × 2 μm.

Rhytisma arbuti Phillips described from *Arbutus* leaves in California (Grevillea *7:* 13 (1878-79)) might be synonymous with *C. arbutifolius*, but no measurements are given.

Colletotrichum acutatum Simmonds ex Simmonds Queensland J. Agric. Animal Sci. *25:* 178 (1968).

Acervuli superficial or subcuticular, pink to pale orange when fresh, drying dark brown, up to 0.5 mm diameter. Setae absent or present occasionally, brown, smooth, septate, tapered, up to 85 μm long and 3-4 μm wide. Conidiophores arising from upper cells of basal pseudoparenchyma, phialidic, simple or branched near the base, short. Conidia hyaline, fusiform, nonseptate, straight, 8-16 × 2.5-4 μm, salmon pink in mass (Fig. 13).

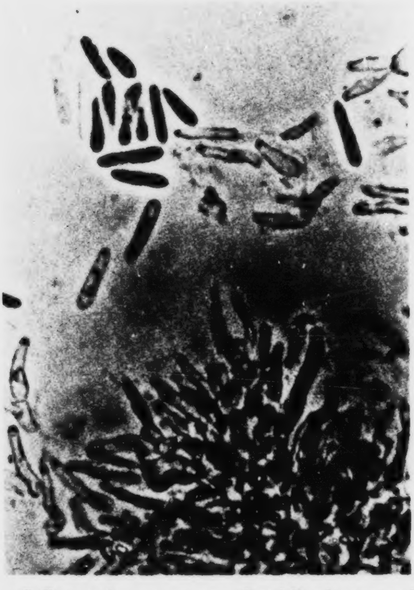


Fig. 13. *Colletotrichum acutatum.* **Conidiophores and conidia.**

Colonies in culture characteristically carmine red, then greyish or black, effuse. Conidia produced in great numbers, usually enclosed in large droplets of mucus on colony surface.

HOST: *Tsuga heterophylla*

DISEASE: Terminal crook of hemlock seedlings in nursery.

NOTES: The *forma specialis* ***pinea*** of *C. acutatum* causes terminal crook of *Pinus* spp. in New Zealand, Australia and Kenya and may have been introduced to Canada where it appeared in 1981 in a forest nursery on the West Coast. The disease has been studied by Dingley and Gilmour (1972), Nair and Corbin (1981)and Nair *et al.* (1983).

Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. Fungi Agrum. *2:*6 (1882).

TELEOMORPH: *Glomerella cingulata* (Stonem.) Spauld. & Schrenk

Acervuli on both sides of leaf, pulvinate, yellowish, 0.5-2 mm diameter, setae not observed, parenchymatous base. Conidiogenous cells enteroblastic, phialidic, hyaline, cylindric, borne on short, cylindric conidiophores that arise from upper cells of acervuli. Conidia hyaline, cylindric to slightly clavate, nonseptate, 12-20 × 4-5 μm (Fig. 14).

Perithecia immersed, brown, subglobose, 100-350 μm diameter, ostiole beaked with external hairs. Asci cylindric, 35-80 × 8-14 μm. Ascospores ellipsoid, hyaline, nonseptate, 12-28 × 4-7 μm. Paraphyses filiform, evanescent.

HOSTS: *Tsuga heterophylla*, *Salix* spp.

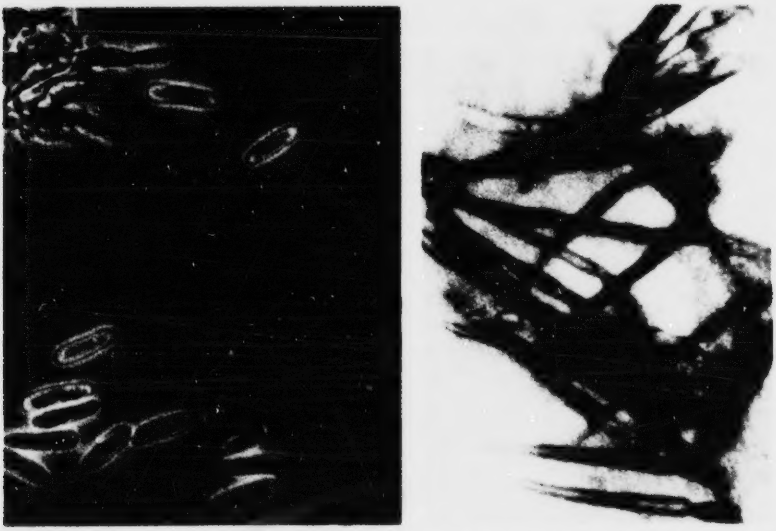


Fig. 14. ***Colletotrichum gloeosporioides.*** **Conidiophores, conidia. Setae.**

DISEASE: Leaf blight and terminal crook of western hemlock seedlings, similar to damage caused by *C. acutatum* (q.v.). Cultures lack the carmine red pigment produced by *C. acutatum.*

NOTES: Description given here is for the fungus as it occurred on hemlock seedlings. As Sutton (1980) has stated "it is clear that *C. gloeosporioides* shows excessively wide variation and for this reason it is meaningless to provide a standardized description." The teleomorph was also found on hemlock.

Cristulariella depraedans (Cooke) Hoehn. Fragmente z. Mykol. 997: 98 (1916).

Macroconidia (propagules) borne singly on apex of conidiophores in necrotic area of leaf. Macroconidia multicellular, subglobose to discoid, hyaline to brown in age, 100-160 μm diameter. Conidiophore erect, septate, solitary, uniseriate, hyaline, unbranched, tapering apically, 100-250 × 8-16 μm. Black sclerotia may form along major leaf veins (Fig. 15).

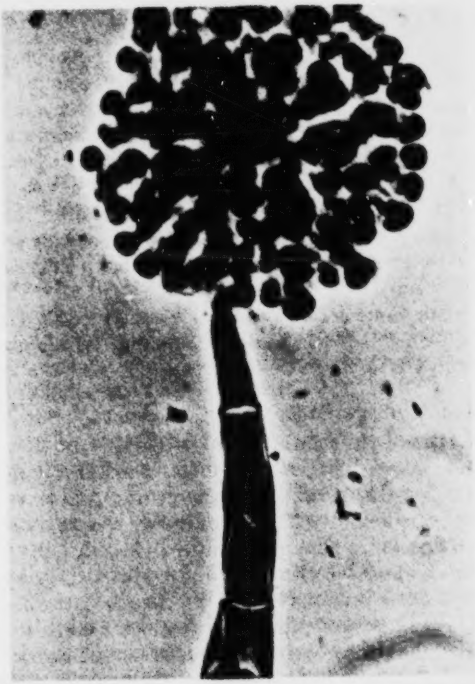


Fig. 15. *Cristulariella depraedans.* Conidiophore with propagule (conidium).

HOSTS: *Acer circinatum*, *A. glabrum* var. *douglasii*

DISEASE: Leaf spot of maple.

NOTE: A zonate leaf spot of broadleaf maple has been found on Vancouver Island that closely resembles that produced by *Cristulariella moricola* (Hino) Redhead but identity of fungus not confirmed.

Cyanodiscus occidentalis E. Muller and Farr Mycologia *63:* 1083 (1971).

Ascocarps superficial, discoid, sessile, blue-green, 215-235 μm diameter, about 80 μm high; wall pseudoparenchymatous with seta-like appendages, flaking away above. Asci bitunicate, ellipsoid to subcylindric, 8-spored, 34-58 × 8-10 μm. Ascospores hyaline to subhyaline, fusiform to clavate, 3-5-septate, not constricted, 12-19 × 3-4 μm. Paraphyses numerous, hyaline, filiform. Free mycelium present, superficial, blue-green.

HOST: *Chamaecyparis nootkatensis*

NOTE: Epiphytic on leaves of yellow cedar (Müller and Farr 1971). Has also been found on bark of *Pinus contorta.*

Darkera abietis Whitney, Reid & Pirozynski Can. J. Bot. *53:* 3052 (1975).

Apothecia hypophyllous, subepidermal, shiny black, ovoid to elongate, up to 1 mm long or if coalescing then up to 2 mm × 0.5 mm, opening by a longitudinal split, covering layer 30 μm thick, of dark pseudoparenchyma; hymenium dull orange, subhymenium pale brown plectenchyma 30 μm thick. Asci clavate, broadest below apex or near the base, short-stalked, pore structure lacking, dehiscing by a bilabiate split, 85-100 × 17-22 μm, usually 8-spored but occasionally 4- to 7-spored. Ascospores hyaline, nonseptate, broadly ellipsoid to reniform, 18-28 × 10-14 μm. Paraphyses about as long as the asci, simple, slightly swollen at the tips. Associated with *Tiarosporella abietis* anamorph (q.v.) but relationship not proven.

HOSTS: *Abies* spp.

NOTES: On *Picea* spp. there is ***Darkera parca*** Whitney, Reid & Pirozynski with ascospores 20-35 × 8-14 μm and associated with the anamorph ***Tiarosporella parca*** (q.v.) (Fig. 15a).

Davisomycella Darker Can. J. Bot. *45:* 1423 (1967).

Ascomata black, conspicuous, innate, short, elliptical to oblong or elongate, subepidermal, with longitudinal slit, parenchymatous. Asci clavate or saccate, 4- or 8-spored. Paraphyses filiform, simple. Ascospores clavate, nonseptate, hyaline, with mucilaginous sheath, at base + attenuated (Figs. 3,4,16). Pycnidia, if present, small, flat, concolorous with needle.

NOTES: *Davisomycella* is represented by six species occurring only on *Pinus* (Table 1). *Lophodermella*, like *Davisomycella*, has clavate, nonseptate ascospores but the ascocarps are concolorous and subhypodermal.

Davisomycella ampla is the most important species. The fruiting bodies occur in straw-colored segments of green needles (Hunt 1981) (Fig. 16). The segments may be separated from the green portions by an orange

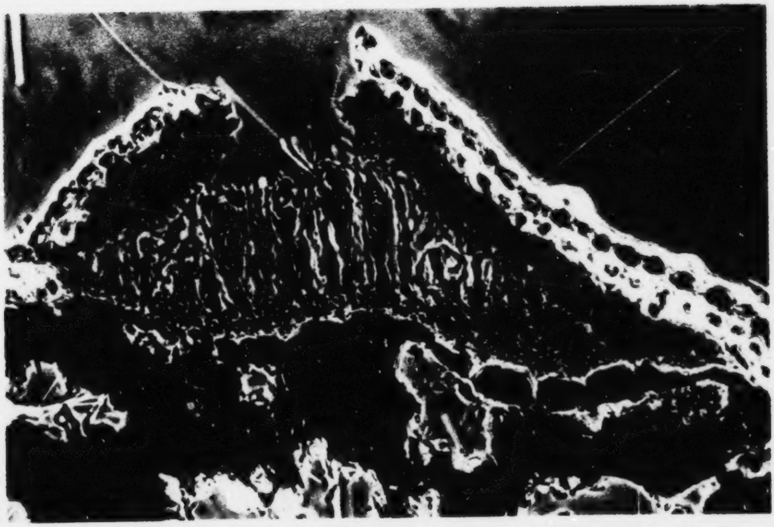


Fig. 15a. *Darkera parca*. Apothecium in spruce needle. (photo by J. Reid).

band. It is subject to secondary invasion by *Sarcotrochila macrospora* in coastal areas preventing ascoma development. (Ziller and Funk 1973).

Delphinella abietis (Rostr.) E. Muller Beitr. Krypt. Schweiz *11*: 26 (1962).

ANAMORPH: *Sclerophoma*

Ascostromata subepidermal, becoming erumpent, on shoots and needles, single or rarely aggregated, black, globose, pseudoparenchymatous, 150-200 μm diameter. Asci cylindric-clavate, bitunicate, 50-90 × 18-22 μm, multispored (16-24), aparaphysate. Ascospores ellipsoid, uniseptate, hyaline, 11-21 × 4-7 μm.

Pycnidia resembling ascostromata, conidia fusiform, hyaline, aseptate, 10-16 × 4-7 μm, produced from cells of inner wall.

HOST: *Abies lasiocarpa*

DISEASE: Parasitic on shoots and leaves of true firs, causing typical reddening of new growth.

NOTES: A closely related species, ***Delphinella balsameae*** (Waterm.) E. Muller, has much larger asci (80-140 × 33-41 μm), and ascospores (30-50 × 7-12 μm), and also occurs on alpine fir. This species was described and studied under the name *Rehmiellopsis* (Waterman 1945).

Delphinella is very similar to the genus *Sydowia*, differing only in that *Sydowia* may have muriform ascospores. Conidial states are also similar in the two genera, and referable to the genus *Sclerophoma*.

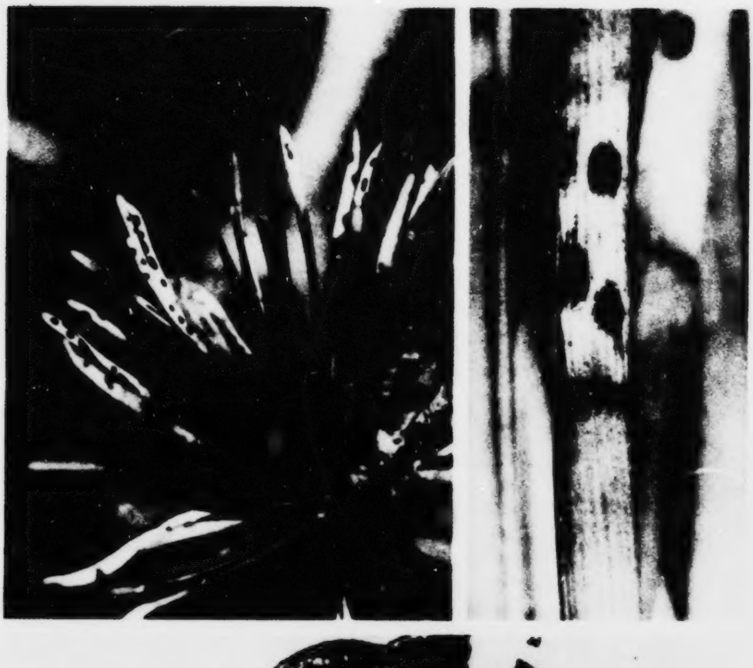


Fig. 16. *Davisomycella ampla*. Ascomata on straw-colored segment which is bordered by dark orange-brown band. *D. medusa*. Vertical section of ascoma on ponderosa pine.

Table 1. *Davisomycella* species (Darker 1967) (Fig. 16)

Species	Hysterothecia	Special Characteristics	Asci	Ascospores	Age of needles	Hosts
D. ampla (Davis) Darker	0.7-1.3 × 0.3-0.6 mm black subepidermal	followed by *Sarcotrochila*, pycnidia concolorous, ascospores not attenuated at base	120-225 × 20-35 μm 8-spored	60-140 × 3-8 μm	1+ yrs living or dead	*Pinus contorta*, *P. banksiana*
D. lacrimiformis (Darker) Darker	0.6-3.5 × 0.2-0.6 mm black subepidermal	asci rarely 4-spored	150-195 × 18-23 μm 8-spored	24-38 × 4.5-6μm	1+ yrs brown area in green needles	*Pinus attenuata*
D. limitata (Darker) Darker	0.8-2.5 × 0.3-0.5 mm black subepidermal	aborted ascospores present	125-160 × 14-15 μm 4-spored	33-45 × 4-4.5 μm	1+ yrs brown area in green needles	*Pinus radiata*
D. medusa (Dearn.) Darker	0.7-21 × 0.4-0.5 mm black subepidermal to subhypodermal		130-180 × 18-27 μm 8-spored	66-80 × 3-6μm attenuated in lower half	on browned needles	*Pinus ponderosa* (Fig. 16), *P. contorta*, *P. jeffreyi*
D. montana (Darker) Darker	1-7.5 × 0.4-0.8 mm black subepidermal	very close to *D. ampla*	180-240 × 30-33 μm 8-spored	70-105 × 5-6 μm clavate	2+ yrs	*Pinus contorta*
D. ponderosae (Staley) Dubin	1-45 × 0.5-1.1 mm black subepidermal	ascomata sinuous to bifurcate	150-210 × 14-22 μm 8-spored	120-170 × 3-4.5 μm filiform	2+ – 5+ yrs on green needles	*Pinus ponderosa*

Dichomera gemmicola Funk & Sutton   Can. J. Bot. *50:* 1514 (1972).

Pycnidia stromatic, unilocular or multilocular, black or dark brown, each locule with a papillate ostiole, outer wall of dark brown to medium brown pseudoparenchyma, inner layer hyaline, thin-walled; unilocular pycnidia 350 μm by 450 μm high, multilocular pycnidia proportionately larger. Conidiogenous cells holoblastic, annellidic, ampulliform to short-cylindric, unbranched, 8-11 × 5-7 μm, produced all around stromatal cavities. Conidia blastospores, produced singly from apex of conidiophore, pale brown, muriform, with 11-17 transverse septa, most cells with several longitudinal septa, cylindric, curved, 70-85 × 12-17 μm (Fig. 17).

HOSTS: *Pseudotsuga menziesii, Picea sitchensis, P. glauca, P. engelmannii*

DISEASE: Causing bud necrosis of *Pseudotsuga* and *Picea*, resulting in deformation, or death of the tree in severe cases.

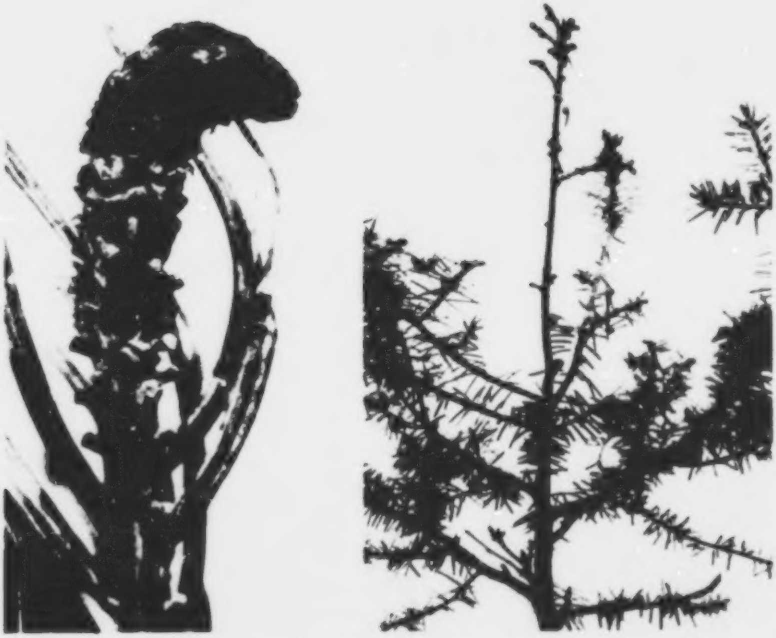


Fig. 17. *Dichomera gemmicola.* Pycnidia on necrotic buds. Damage from severe attack on Douglas-fir.

Fig. 18. *Didymascella thujina*. Ascomata on western red cedar.

Didymascella thujina (Durand) Maire Bull. Soc. Hist. Nat. Afr. Nord *18:* 120 (1927).

SYNONYM: *Keithia thujina* Durand

Ascomata chiefly on upper surface of needles, subepidermal, roughly circular in outline, olive brown, up to 1 mm diameter; hymenium not covered by fungal tissue, exposed by rupture of overlying epidermis. Ascomata may fall out entirely when spent, leaving a pit in the leaf. Asci clavate, 2-spored, pore not bluing in iodine (J-), 100 × 20 μm. Ascospores ellipsoid, thick-walled, 1-septate near the upper end, walls pitted, brown, 22-25 × 15-16 μm, with a gelatinous sheath. Paraphyses filiform, branched, thickened at the tips.

HOST: *Thuja plicata*

DISEASE: Needle blight of red cedar (Fig. 18).

LIFE CYCLE: Infection of current year's foliage occurs in spring or summer from ascospores produced in the previous year's infected foliage (Porter 1957).

Didymosporium arbuticola Zeller Mycologia *26:* 303 (1934).

Acervuli hypophyllous, erumpent through epidermis, circular, 130-240 μm diam. Conidiophores simple, short, hyaline. Conidia acrogenous, oblong-ellipsoid, light brown, 1-(3-)septate, slightly constricted at septum, 19-29 × 7-8 μm (Fig. 19).

HOST: *Arbutus menziesii*

DISEASE: Leaf spot of arbutus. Spots are brown with purplish to reddish margins, 3-6 mm diam, in living leaves (Hunt and Funk 1983). A somewhat similar spot on arbutus leaves is produced by the rust fungus *Pucciniastrum sparsum* (Wint.) E. Fischer whose urediniospores are 26-45 × 12-20 μm (Ziller 1974).

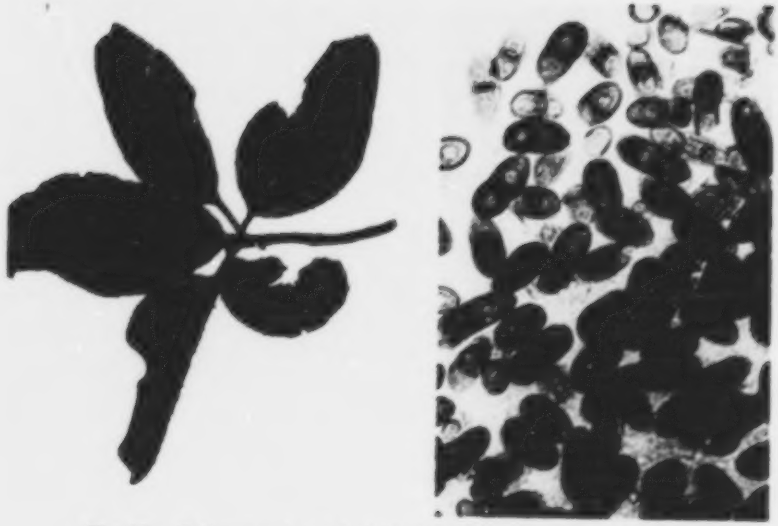


Fig. 19. *Didymosporium arbuticola.* Leaf spot on *Arbutus.* Conidia.

Diplodia pinea (Desm.) Kickx Fl. Flandres *1:*397 (1867).

SYNONYM: *Sphaeropsis sapinea* (Fr.) Dyko & Sutton

Pycnidia black, ovoid, immersed then erumpent, solitary or gregarious, with apical ostioles; pycnidial wall thickened around the top, 0.5 mm diameter. Conidiophores simple, subulate, about half as long as the conidia. Conidia (blastoconidia) yellow to dark brown, wall roughened, oblong to clavate, apex rounded, base blunt, aseptate to tardily 1-septate, 30-45 × 10-16 μm (Fig. 20).

HOSTS: *Pinus* spp. chiefly, but also many other conifers

DISEASE: May cause browning of needles. Rare in western Canada.

Dothiora taxicola (Peck) Barr Contr. Univ. Mich. Herb. *9:*575 (1972).

ANAMORPH: *Cytospora*

Ascomata densely scattered, epiphyllous, subepidermal, subglobose with erumpent apex, 130-240 × 145-165 μm; wall pseudoparenchymatous, black, 14-30 μm thick, apical region paler. Asci clavate, bitunicate, 8-spored, 60-96 × 9-15 μm. Ascospores hyaline, ellipsoid, 1-3-septate, 13-18 × 3-5 μm (Fig. 21).

Pycnidia immersed, subglobose, approximately 400 μm diameter. Conidiophores 7-15 × 2 μm. Conidia hyaline, nonseptate, 3-5 × 1 μm.

HOST: *Taxus brevifolia*

DISEASE: Needle- and shoot-blight of yew.

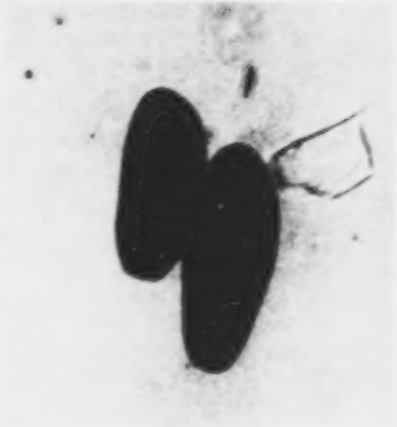


Fig. 20. *Diplodia pinea*. Conidia.

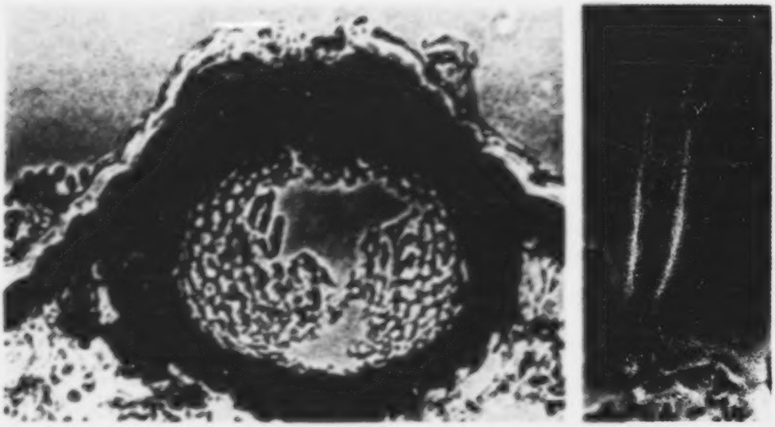


Fig. 21. *Dothiora taxicola*. Ascoma, vertical section. Ascus with ascospores.

Elytroderma deformans (Weir) Darker Contr. Arnold Arbor. *1*: 62 (1932).

ANAMORPH: *Leptostroma*

Ascomata appear as narrow, black lines (slits) of varying lengths, chiefly on the abaxial surface of the browned needles, up to 10 mm long; opening by a longitudinal split to expose the pale brown hymenium. The subepidermal clypeus of black cells covers only the central part of the hymenium. The subhymenium is hyaline and thin. Asci saccate to fusiform- clavate, 8-spored, 140-240 × 30-45 μm. Ascospores hyaline, cylindric, 1-septate, 90-120 × 6-9 μm, with thick gelatinous sheath. Paraphyses filiform, simple, septate (Figs. 3, 4, 22).

Conidiomata concolorous with needle, subepidermal, up to 1.2 mm long, blister-like. Conidiophores 12-15 μm long, arising from a thin basal layer, ampulliform, simple. Conidia terminal, hyaline, bacillar, 6-8 × 1 μm.

HOSTS: *Pinus ponderosa, P. contorta* and other 2- and 3-needle pines.

DISEASE: Causes browning of needles; may enter shoots and cause brooming of branch ends by a systemic, perennial infection of the bark (Fig. 22).

LIFE CYCLE: Current year needles are infected by ascospores shot in mid to late summer or by mycelium from perennial infections in bark of twigs. Infected needles gradually discolor (parts may remain green); conidiomata form in the following spring and ascomata begin to form in June, with ascospores maturing in late summer. (Childs 1959, 1968; Scharpf and Bega 1981).

Entomosporium mespili (DC. ex Duby) Sacc. Michelia *2:* 115 (1880).

TELEOMORPH: *Diplocarpon mespili* (Sorauer) Sutton

SYNONYM: *Fabraea maculata* Atk.

Acervuli circular, single or confluent, subcuticular, up to 200 μm diameter. Conidiophores septate, cylindrical, straight or flexuous, branched at the base, hyaline, 15 × 3-4 μm. Conidiogenous cells holoblastic, terminal, with a single conidium. Conidia resembling an insect, consisting of basal and upper cells with two or more lateral, smaller cells, all subglobose, apical and lateral cells with simple, single, flexuous appendages, 15-22 × 5-10 μm long (Fig. 23).

Apothecia cupulate, dark brown, pseudoparenchymatous. Asci clavate-cylindric, 8-spored, pore J+, 60-95 × 18-24 μm. Ascospores narrowly ovoid, 1-septate, hyaline, 16-24 × 6-10 μm.

HOSTS: *Crataegus, Amelanchier, Sorbus*

DISEASE: Leaf spot and blight or scald.

NOTES: Transmission chiefly by rain-splashed conidia. Overwinters as mycelium in cast leaves, producing conidia in the spring. Defoliation occurs in midsummer (Sivanesan and Gibson 1976; Horie and Kobayashi 1980).

Epicoccum nigrum Link Mag. Ges. naturf. Fr. Berl. *7:* 32 (1815).

Sporodochia black, pulvinate, up to 2 mm diameter. Mycelium mostly immersed, stromata present. Conidiophores densely packed on stromata, mostly simple, 5-15 × 3-6 μm. Conidiogenous cells monoblastic, terminal, cylindric. Conidia solitary, dry, acrogenous, globose to pyriform, brown, often with a pale basal stalk cell, muriform but septa obscured by rough, opaque wall, 15-25 μm diameter, occasionally to 50 μm. (Fig. 24).

HOSTS: Conifers and hardwoods

DISEASE: Colonizes leaves and needles. Saprophytic or weakly parasitic.

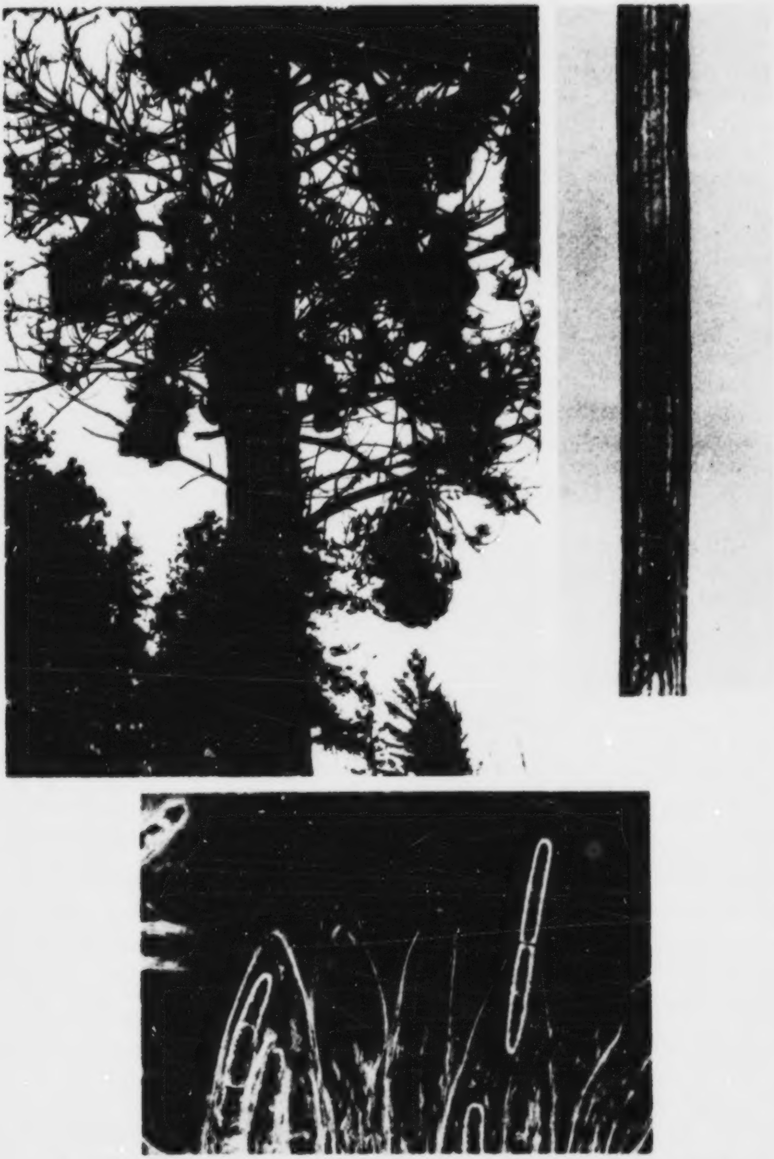


Fig. 22. *Elytroderma deformans.* Brooming produced in ponderosa pine. Ascomata in needles. Ascospores emerging from asci.

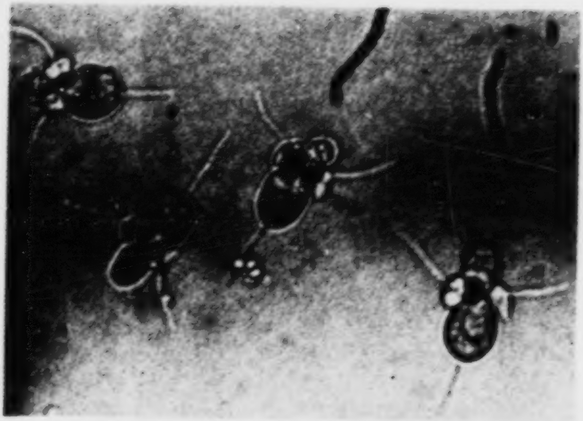


Fig. 23. *Entomosporium mespili.* Conidia.

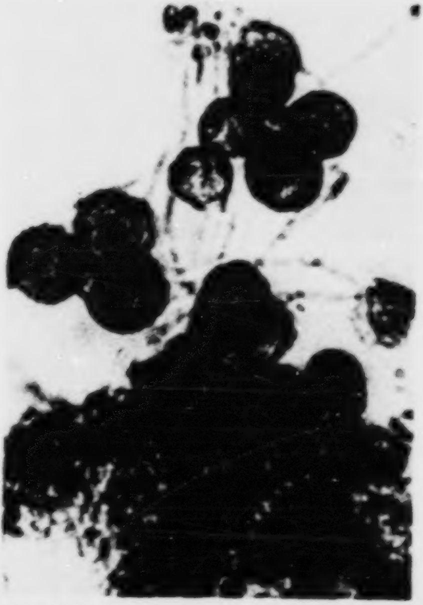


Fig. 24. *Epicoccum nigrum.* Sporodochium and conidia.

Epipolaeum abietis (Dearn.) Shoemaker Can. J. Bot. *43:* 634 (1965).
SYNONYM: *Dimerosporium abietis* Dearn.

Perithecia hypophyllous, clustered on radiating, superficial mycelium that enters needle only at stomata and bears orange crystals, globose, setose, 120-180 μm diameter, with a short yellowish beak lined with periphyses. Asci in a basal cluster, bitunicate, saccate, 8-spored, 50-70 × 20-36 μm. Paraphyses absent. Ascospores ovoid, hyaline to light brown, 1-septate at the middle, upper cell broader, 24-36 × 6-9 μm (in age rarely 3-septate and finely roughened).

HOSTS: *Abies amabilis, A. grandis, A. lasiocarpa*

DISEASE: "Black mildew." Conspicuous black colonies on needles (Fig. 25).

NOTE: On living or dead needles.

Epipolaeum tsugae (Dearn.) Shoemaker Can. J. Bot. *43:* 635 (1965).
SYNONYM: *Dimeriella tsugae* (Dearn.) Petr.

Perithecia hypophyllous, clustered on superficial, radiating mycelium that enters needle only at stomata and bears orange crystals, globose, setose, 70-100 μm diam, ostiolar area yellowish, with inner periphyses. Asci in basal cluster, bitunicate, saccate, 8-spored, 36-50 × 9-15 μm. Paraphyses absent. Ascospores hyaline, ovoid, 1-septate at the middle, upper cell broader, 18-21 × 3-5 μm.

HOSTS: *Tsuga heterophylla, Picea glauca*

DISEASE: "Black mildew." Conspicuous black colonies under leaves (Fig. 25).

NOTES: On living or dead needles. *E. pseudotsugae* (V.M. Miller & Bonar) Shoem. occurs on Douglas-fir needles, is similar to the above but has smaller asci (30-40 × 6-10 μm) and ascospores (9-12 × 3 μm).

Fabrella tsugae (Farlow) Kirschst. subsp. *grandispora* Ziller Mycologia *54:* 28 (1962).

Ascomata subepidermal, yellowish-red to dark yellowish-brown, ellipsoid, exposing hymenium by rupturing the epidermis. Asci cylindric, 4-spored, 70-95 μm long. Ascospores at first hyaline, 1-celled, becoming 2-celled and greenish-brown at maturity, constricted at the septum, 16-21 × 8-10 μm.

HOST: *Tsuga heterophylla*

DISEASE: Needle blight of western hemlock. Rare and usually sparse infections.

Gloeosporium "corni"

Acervuli brown, pulvinate, small, irregular, often along leaf veins. Conidiophores phialidic, subulate, simple or branched, pointed at the tips, hyaline. Conidia hyaline, nonseptate, ellipsoid-fusiform, guttulate, mostly 8 × 2 μm (Fig. 27).

HOST: *Cornus nuttallii*

DISEASE: Leaf blotch of flowering dogwood. Blotches frequently centered on mid-vein giving a wedge-shaped appearance (Fig. 26) (anthracnose).

NOTES: *Phyllosticta cornicola* has also been linked to leaf blotch of dogwood in the west (q.v.).

Arx (1970) considered *Gloeosporium corni* Greene and *G. corni* Woron. to be the same as *Colletotrichum gloeosporioides* which has much larger conidia than the *Gloeosporium* described here.

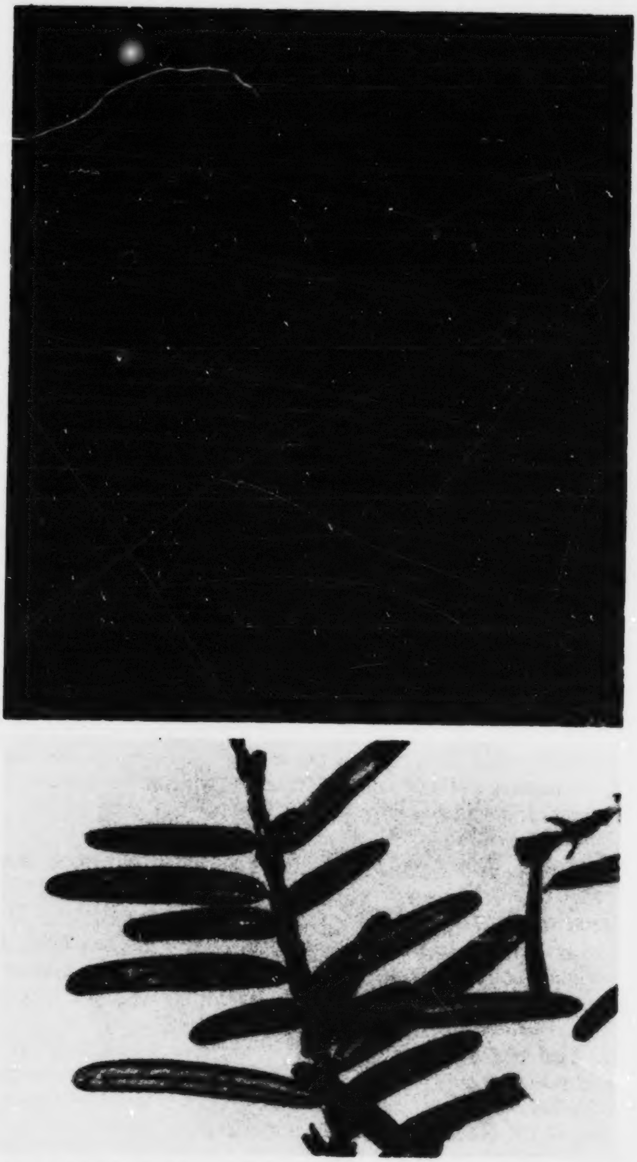


Fig. 25. *Epipolaeum abietis.* "Black mildew" on grand fir. *E. tsugae*, colonies on western hemlock.

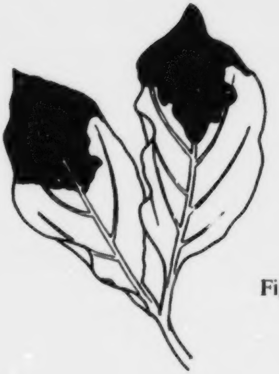


Fig. 26. *Gloeosporium* "*corni*". Leaf blotching of flowering dogwood.

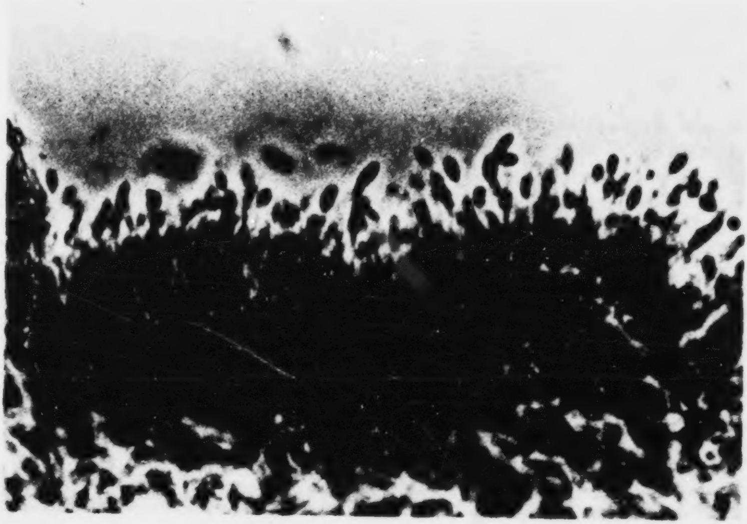


Fig. 27. *Gloeosporium* "*corni*". Sporodochium and conidia.

Gnomonia setacea (Pers.) Ces. & de Not. Mycol. Europ. *5 & 6:* 27 (1869).

Perithecia mainly hypophyllous, black, immersed in leaf, 200-300 µm diam; ostiole more than 500 µm long, 25-40 µm thick at the base, protruding from leaf. Asci 35-45 × 6-8 µm, clavate, 8-spored. Ascospores hyaline, fusiform, straight, 1-septate, 14-16 × 2 µm.

HOSTS: *Alnus*

DISEASE: Leaf browning and early abscission (anthracnose).

NOTES: The recent revision of Gnomoniaceae (Monod 1983) places some doubt on the identification of this fungus. One specimen identified as *G. setacea* had ascospores up to 35 × 4 µm.

G. campylostyla Auers. causes a similar disease in *Betula glandulosa*. ***Gnomonia quercina*** Kleb. is reported on *Quercus macrocarpa*. ***G. veneta*** Kleb. that attacks *Platanus* leaves is common some years in the ornamental plantings; its conidial state only is usually present (conidia 10-14 × 4-6 µm, oozing out of acervuli in white masses). Refer to Monod (1983) for revised names.

Gremmeniella abietina (Lagerberg) Morelet Bull. Soc. Sci. Nat. Arch. Toulon *183*:9 (1969).

ANAMORPH: *Brunchorstia pinea* (Karst.) Hoehn.

Apothecia dark brown, short-stalked, erumpent, cup-shaped, folded when dry, inrolled margin, 1 mm diameter; excipulum of *textura angularis*; hymenium pale to cream-colored; hypothecium hyaline. Asci cylindric, 8-spored, J-, 110-120 × 8-10 µm. Ascospores hyaline, 4-celled, ellipsoid, 15-22 × 3-5 µm. Paraphyses hyaline, filiform, forming an epithecium.

Pycnidia dark brown, erumpent, subglobose to irregular, thick-walled, 0.4-0.5 mm diameter; conidiophores simple, short, probably phialidic, lining inner wall; conidia curved to sickle-shaped, fusoid, hyaline, up to 4-celled, 25-50 × 3-4 µm (Fig. 28).

HOSTS: *Pinus contorta, P. ponderosa, P. albicaulis*

DISEASE: Foliar symptoms in early summer are yellowing or reddening of needle bases. Later the entire needle turns brown. The fungus infects through the needles but then may invade branches causing dieback and "Scleroderris Canker" of stems. It is usually the pycnidial state that is found on the needles. The disease has been found only at a few scattered locations in western Canada and impact so far has been negligible. See reports by Dorworth (1970, 1972).

Hemiphacidium longisporum Ziller & Funk Can. J. Bot. *51:* 1960 (1973).

Apothecia amphigenous, sessile, subepidermal then erumpent to produce a circumscissile lid of epidermis, circular to polygonal, 200-500 × 300-600 µm; excipulum poorly developed, dark reddish-brown, 20-30 µm thick, of short-celled hyphae. Hymenium olive-brown, without covering layer. Asci cylindrical to

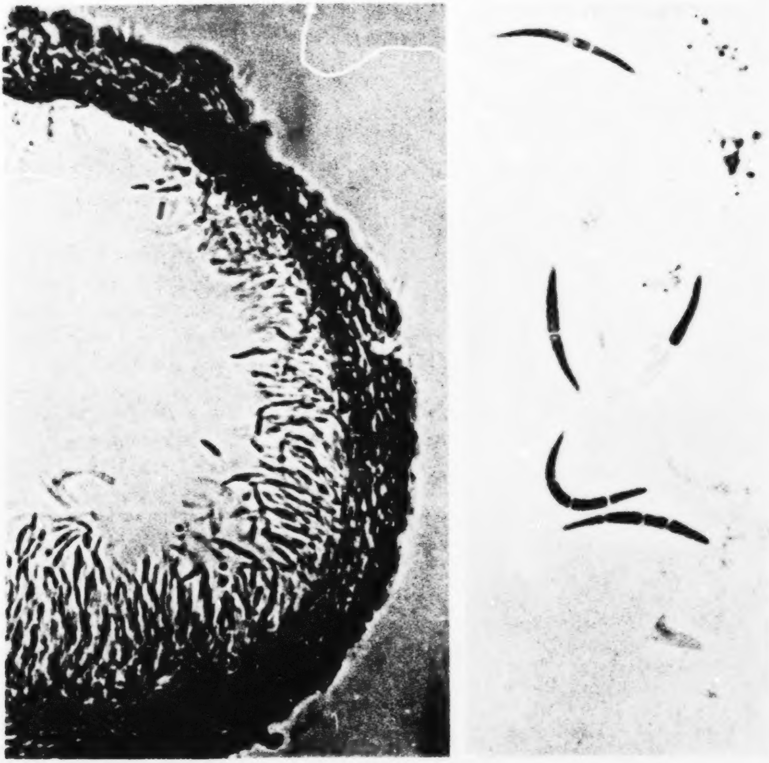


Fig. 28. *Gremmeniella abietina. Brunchorstia* anamorph and conidia.

clavate, 8-spored, pore of apex not staining in iodine (J-), 60-100 × 10-14 µm. Ascospores narrowly clavate, hyaline, nonseptate, 45-70 × 2-3 µm, basal end 1.5 µm, frequently with knob. Paraphyses filiform, septate, sometimes branched, swollen at the apex (Fig. 29).

HOST: *Pinus contorta*

DISEASE: Secondary invader of needles attacked by *Lophodermella concolor* (Table 5).

NOTE: This fungus was found only on 1-year-old needles on trees growing not more than 1.6 km from the seashore.

Hemiphacidium planum (Davis) Korf Mycologia *54*:27 (1962).

Apothecia sessile, subepidermal then erumpent to produce a lid of epidermis, irregular in outline, 1-2 mm long; excipulum poorly developed, of hyaline hyphae.

Fig. 29. *Hemiphacidium longisporum.* Apothecia on lodgepole pine. *Hemiphacidium planum.* Ascospores.

Hymenium brown, plane, without covering layer. Asci clavate, 8-spored, 80-110 × 14-18 μm, J-. Ascospores fusoid-clavate, hyaline, nonseptate, 25-40 × 4-6 μm. Paraphyses filiform (Fig. 29).

HOSTS: *Pinus* spp.

DISEASE: Secondary invader of pine needles attacked by various hypodermataceous needle fungi (Table 5).

NOTE: Differs from *H. longisporum* chiefly in its shorter ascospores and wider distribution.

Hendersonia pinicola Wehmeyer   Mycologia *38:* 312 (1946).

Pycnidia black, subglobose, immersed, wall prosenchymatous, 100-150 μm diam, with apical pore. Conidiophores absent. Conidiogenous cells hyaline, lining inner wall. Conidia dark brown, fusoid-ellipsoid, 3-septate at maturity, not constricted at septa, 12-20 × 4-7 μm, oozing out in a black, irregular cirrhus (Fig. 30).

HOSTS: *Pinus*

DISEASE: Secondary invader of pine needles attacked by hypodermataceous needle parasites, especially *Lophodermella concolor* (Table 5), and believed to act as a biological control agent.

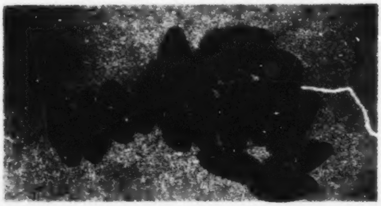


Fig. 30. *Hendersonia pinicola.* Conidia.

Herpotrichia coulteri (Peck) Bose   Phytopath. Z. *41:* 195 (1961).

SYNONYM: *Neopeckia coulteri* (Peck) Sacc.

Pseudothecia globose, dark brown, single or in small groups, formed on a subiculum of felty brown hyphae, 250-500 μm diameter, with a distinctly papillate pore, wall of thick-walled pseudoparenchyma, covered by brown hyphae. Asci cylindrical, short-stalked, bitunicate, 8-spored, 140-210 × 14-20 μm. Ascospores monostichous, elliptical, dark brown, 1-septate, constricted, with a dark epispore, 10-28 × 7-10 μm. Pseudoparaphyses hyaline, septate, filiform, sparsely branched.

HOSTS: Chiefly on *Pinus*, rarely on *Picea*

DISEASE: Causes snow mould, invading and killing foliage when it is covered by snow, therefore affecting lower branches or very young trees, especially in nurseries. A brown, felt-like mycelium covers the branches, penetrating the cuticle, and producing microsclerotia. Branch dieback or death of seedlings may result. Also called "brown felt-blight."

Fungicides maneb and zineb applied before first snowfall control the disease.

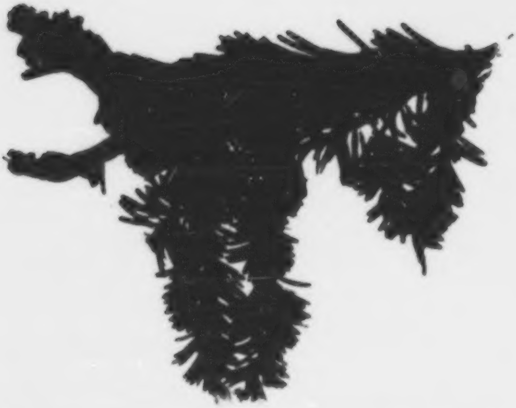


Fig. 31. *Herpotrichia juniperi*. Snow mould of alpine fir.

Herpotrichia juniperi (Duby) Petr. Ann. Mycol. *23:*43 (1925).
SYNONYM: *Herpotrichia nigra* Hartig

Pseudothecia dark brown, globose, sparsely gregarious, partly hidden in a felt-like subiculum of dark brown hyphae, 200-450 μm diameter, with a definite apical pore, wall of polygonal cells 20-40 μm thick, covered with brown, septate hyphae. Asci cylindric to subclavate, 8-spored, bitunicate, 115-190 × 12-18 μm. Ascospores monostichous or obliquely distichous, hyaline and 1-septate at first, becoming brown and 3-4-septate, elliptical, constricted at median septum, with a mucus sheath, 25-34 × 8-12 μm. Pseudoparaphyses filiform, hyaline.
HOSTS: *Abies, Chamaecyparis, Juniperus, Picea, Pinus, Tsuga*
DISEASE: Brown felt blight or snow mould. Similar to *H. coulteri* (Fig. 31).
NOTE: After snowmelt, fruit bodies form on mycelium and release spores.

Hormonema merioides Funk, Woods and Hopkinson Can. J. Botany *63* (1985) (in press)

Sporodochia hypophyllous, sessile in stomates, columnar, brown, 50-110 μm diameter, enclosed in mucus. Conidiophores simple, septate, emerging from stomates in a fascicle, 2-3 μm diameter. Conidiogenous cells in chains of four, monophialidic, at first promycelial, then becoming subglobose or rectangular, sometimes branching, 8-13 × 8-10 μm. Conidia hyaline, ellipsoid, to ovoid, nonseptate, 0-2 guttulate, 6-11 × 4-6 μm; at germination becoming brown and 1-septate.
HOST: *Pseudotsuga menziesii, Abies grandis*
DISEASE: Associated with needle blight under conditions of very high moisture. A brick red discoloration of the distal half of the needle with a clear separation between living and infected tissue is the chief symptom (Fig. 31a).

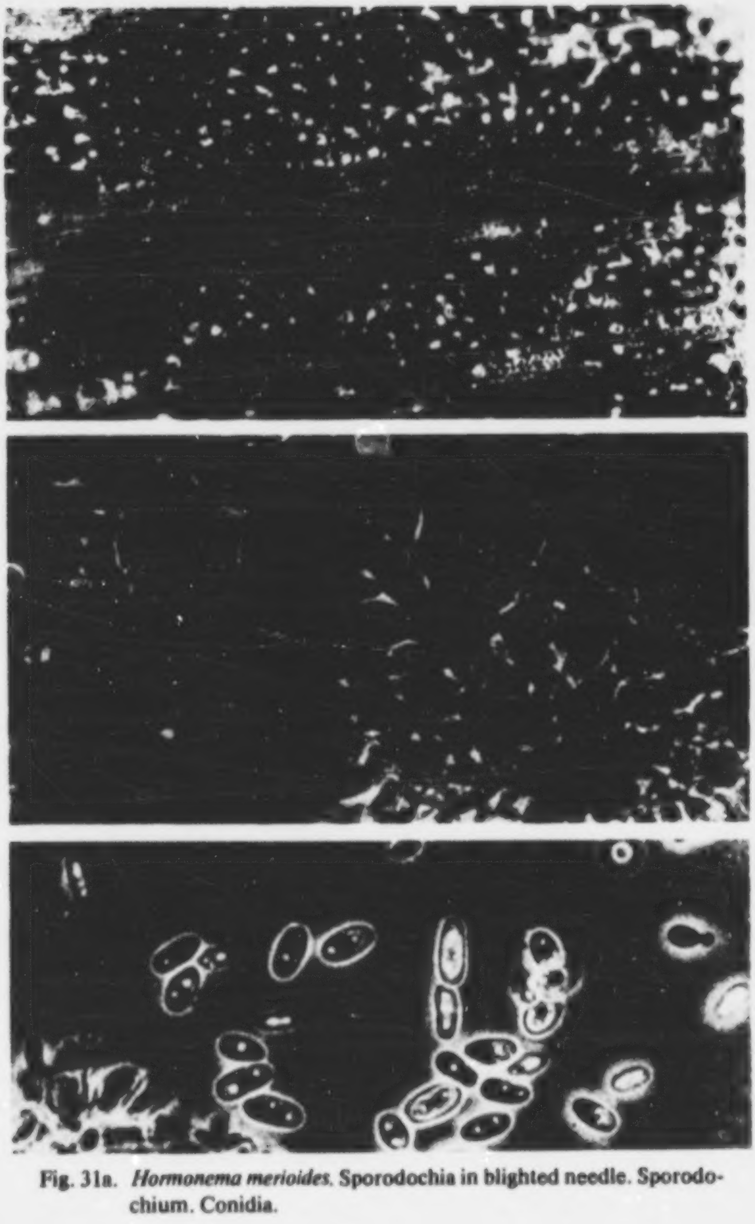


Fig. 31a. *Hormonema merioides.* Sporodochia in blighted needle. Sporodochium. Conidia.

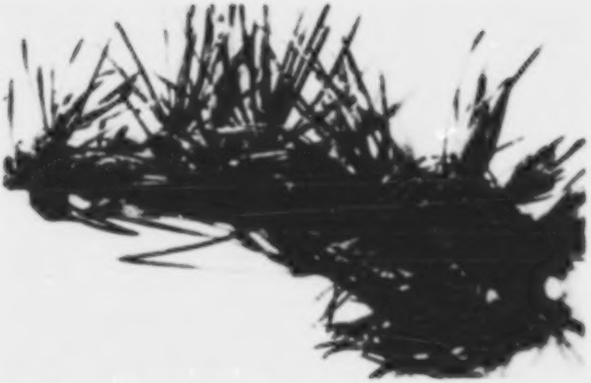


Fig. 32. *Hypodermella laricis.* Blighted needles on western larch.

Hypodermella laricis Tub. Bot. Centralbl. *61:* 49 (1895).

ANAMORPH: *Leptothyriella laricis* Dearn.

Hysterothecia black, elliptical, subcuticular, more or less in a continuous row, 0.5-0.8 × 0.2-0.3 mm; a basal layer of brown pseudoparenchyma subtends a plectenchymatous layer 10-15 µm thick below the hymenium; covering layer dark without evident opening mechanism. Asci clavate, 4-spored usually, acutely pointed at maturity, 80-112 × 20-24 µm. Ascospores clavate tapering to an acute base, hyaline, nonseptate, with gelatinous sheath 5 µm thick, 70-105 × 6 µm. Paraphyses shorter than the asci, filiform, slightly swollen at the tips (Figs. 3,4).

Pycnidia black, numerous, 120-300 × 80-120 µm. Conidia hyaline, elongated pyriform, 4-5 × 1 µm.

HOSTS: *Larix occidentalis, L. laricina, L. lyallii*

DISEASE: Needle blight. Diseased needles retained after normal needle drop (Fig. 32). All needles on a spur turn reddish-brown. Only newly flushed needles are susceptible.

NOTE: Benomyl and maneb fungicides applied repeatedly during flushing will protect needles.

Isthmiella abietis (Dearn.) Darker Can. J. Bot. *45:* 1420 (1967).

SYNONYM: *Bifusella abietis* Dearn.

Hysterothecia usually continuous along lower surface midrib of needle, intraepidermal but becoming subepidermal at the sides, black, 420-455 µm wide, 210-280 µm deep, basal layer of plectenchyma 30-35 µm thick continuing up the sides in a narrow band. Asci clavate, thin-walled, rounded at the tip, 8-spored, 115-160 × 28-30 µm. Ascospores bifusiform with narrow connecting isthmus, hyaline, with thick gelatinous sheath, 40-50 × 4-6 µm. Paraphyses filiform, hyaline, with thin gelatinous sheath, 110-120 × 1 µm (Fig. 4).

Pycnidia epiphyllous, intraepidermal, concolorous with needle, along both wings of needle, 140-240 μm wide.

HOST: *Abies lasiocarpa*

DISEASE: Needle blight of 1 + -yr-old needles.

NOTE: The secondary fungi *Leptosphaeria faullii*, *Lophomerum autumnale* and *Stegopezizella balsameae* may invade the needles and prevent maturation of *Isthmiella* ascospores.

Lirula abietis-concoloris sometimes occurs in same trees.

Isthmiella crepidiformis (Darker) Darker Can. J. Bot. *45*: 1420 (1967).

Hysterothecia black, conspicuous, hypophyllous, narrowly ellipsoid, opening longitudinally, 0.5-3.0 × 0.3-0.6 mm, intraepidermal; basal layer plectenchymatous, 20-40 μm thick; covering layer dark pseudoparenchyma, with epidermis 40-63 μm thick. Asci clavate-truncate, 8-spored, 145-165 × 24-28 μm. Ascospores bifusiform, slightly constricted in the middle, hyaline with thick gelatinous sheath, 60-75 × 8-8.5 μm (Fig. 4).

HOSTS: *Picea engelmannii*, *P. glauca*, *P. mariana*

DISEASE: Needle blight.

NOTE: This disease is more common north of latitude 62°. Ascomata found only on needles older than two years, at which age many needles drop naturally. Ascomata outwardly resemble *Lirula macrospora*.

Isthmiella quadrispora Ziller Can. J. Bot. *46*: 1378 (1968).

Ascomata maturing in yellow, dead needles still attached, chiefly hypophyllous, nervisequious along entire needle or interrupted, black, subcuticular at first, but becoming subepidermal at the sides, 300-400 μm wide, opening by a conspicuous slit with lips 40-60 μm thick. Hymenium pale yellow. Basal layer 15-30 μm thick. Asci 4-spored, truncate-clavate tapering to long stipe, 90-140 × 14-18 μm. Ascospores unequally bifusiform, nonseptate, isthmus 2-3 μm diam, basal part longer and narrower than upper part, hyaline, in gelatinous sheath 1-5 μm thick, 40-55 × 3-6 μm. Paraphyses filiform, septate, slightly swollen at tips, sheathed, approximately 130 × 1 μm (Fig. 33).

Pycnidia absent.

HOST: *Abies lasiocarpa*

DISEASE: Needle blight.

NOTES: The fungus has a two-year life cycle, i.e., it takes two years from infection to production of ascospores, resulting in alternate year's needles being infected, since only new needles susceptible (Fig. 33).

Secondary fungi *Stegopezizella balsameae* and *Lophomerum autumnale* may prevent maturation of *I. quadrispora*.

Kabatina thujae Schneider & Arx Phytopath. Z. *57*: 180 (1966).

Acervuli erumpent, brown, up to 150 μm diameter, separate or confluent, pulvinate, formed of brown, thick-walled pseudoparenchyma, often vertically elongated and cylindrical towards top. Conidiophores pale brown or hyaline, branched at the base. Conidiogenous cells enteroblastic, phialidic, dolioform or

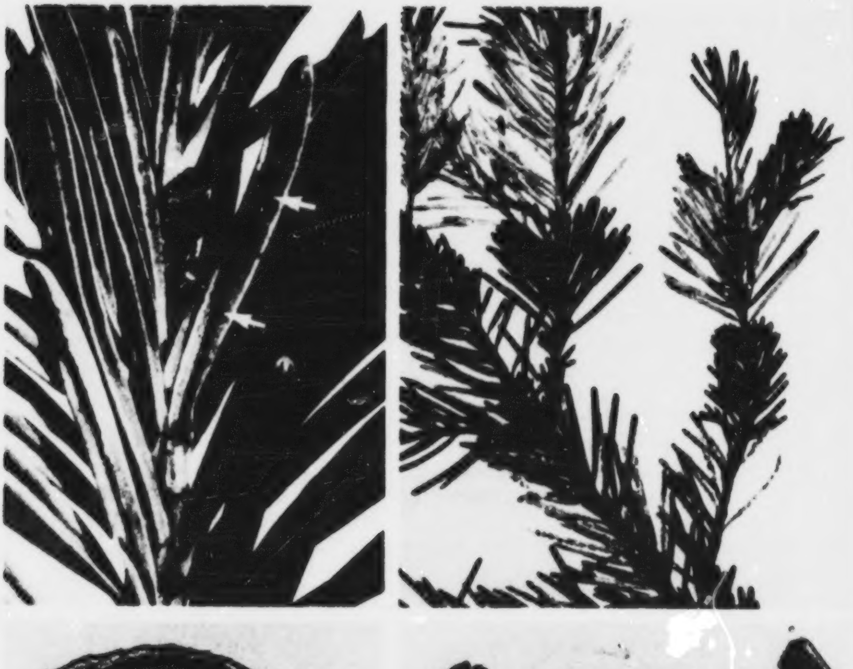


Fig. 33. *Isthmiella quadrispora*. Blighted needles on alpine fir. Ascoma on needle. Ascoma, vertical section, showing subcuticular development and mature position.

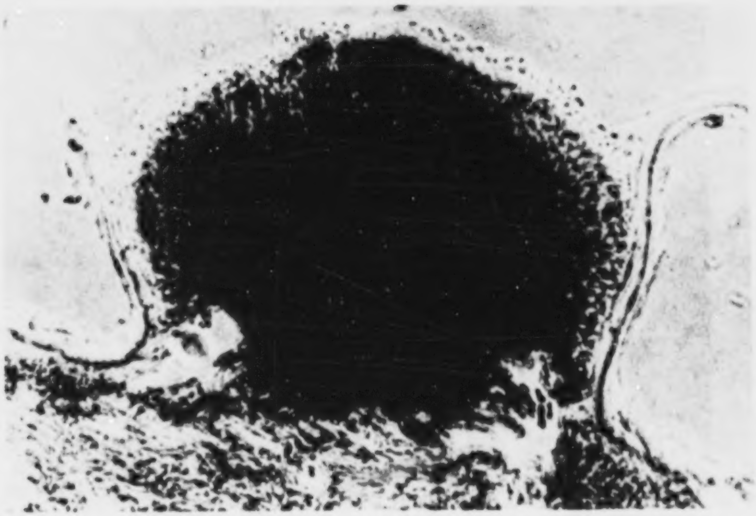


Fig. 34. *Kabatina thujae*. Conidioma in bark of yellow cedar. Conidia.

ampulliform, terminal or lateral, 6-8 × 4-5 μm. Conidia hyaline, nonseptate, ellipsoid, 5-8 × 2-3 μm (Fig. 34).

In agar culture almost black; conidia less than 8 μm long produced directly from the dark, septate hyphae (*Hormonema*-like).

HOST: *Chamaecyparis nootkatensis*

DISEASE: Causes leaf and shoot blight of yellow cedar. An epidemic on ornamental varieties was reported in Fraser Valley nurseries by Funk and Molnar (1972). Cultural characteristics were described by Hermanides-Nijhof (1977).

NOTES: A closely related species, ***K. juniperi*** Schneider & Arx, is found on *Juniperus* spp. in the Great Plains (Ostrofsky and Peterson 1981) that differs slightly in cultural characteristics.

Leptomelanconium cinereum (Dearn.) Morgan-Jones Can. J. Bot. *49:* 1012 (1971).

SYNONYM: *Gloeocoryneum cinereum* (Dearn.) Weindl., *L. pini* (B. & C.) Hunt

Acervuli hypodermal then erumpent, black, irregular to circular in outline, up to 600 μm diameter, composed of hyaline to subhyaline isodiametric pseudoparenchyma. Conidiophores hyaline, smooth-walled, short, cylindric to subulate. Conidiogenous cells long, cylindric, 15-30 × 3 μm, without annellations. Conidia brown, ovoid to ellipsoid, thick-walled, verrucose, 3-(5-) septate, obtuse at the apex narrowing to a truncate base which bears a marginal frill, 20-25 × 6-12 μm (Fig. 35).

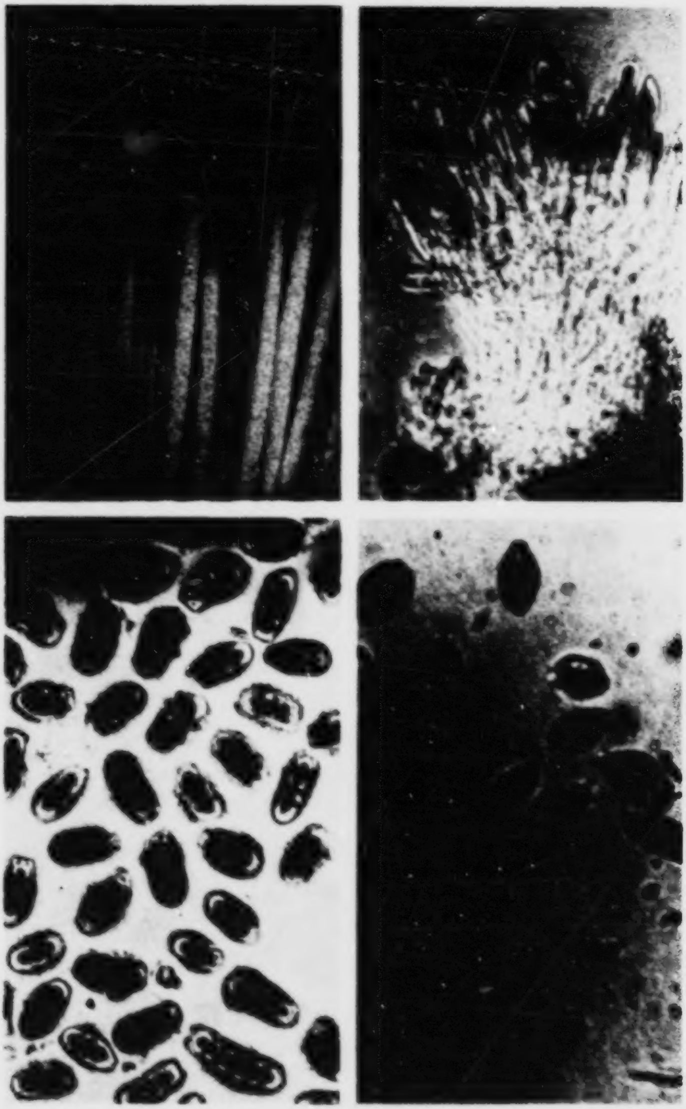


Fig. 35. *Leptomelanconium cinereum*. Conidiomata in pine needles. Conidia. *L. allescheri*, conidia.

HOSTS: *Pinus* spp.

DISEASE: Appears to cause needle blight of pines on needles of all ages but causal relationship is not proven.

NOTES: The long conidiogenous cells without annellations and 3-septate conidia favor *Gloeocoryneum* for this fungus (Sutton 1980).

A rare species on needles of white pine is ***L. allescheri*** (Schnabl) Petr. with nonseptate, verruculose, navicular conidia, 8-12 × 4-5 μm (Sutton and Chao 1970) (Fig. 35).

Leptosphaeria faullii Darker Can. J. Bot. *42:* 1006 (1964).

ANAMORPH: *Coniothyrium faullii* Darker

Perithecia scattered in needles attacked by hypodermataceous fungi of the nervisequious habit, subepidermal, subglobose, wall of dark pseudoparenchyma, ostiolate to upper surface of needle, 260-280 × 170-235 μm. Asci clavate, 8-spored, cytoplasm reddish-brown in iodine, tip J-, 80-110 × 9-15 μm. Paraphyses simple, septate, filiform, hyaline, thinly sheathed. Ascospores biseriate to uniseriate, fusoid-ellipsoid, yellowish brown, 3-septate, slightly constricted at septa, with gelatinous sheath, 15-23 × 4-6 μm.

Pycnidia resembling perithecia in form and habit. Conidiophores simple, septate or occasionally branched, up to 45 μm long. Conidiogenous cells phialidic at apex or below septa. Conidia ellipsoid, dark brown, 5-8 × 4-6 μm.

HOST: *Abies lasiocarpa*

NOTE: Secondary invader of needles attacked by *Isthmiella abietis.* An agent of biological control of needle parasites; may prevent fruiting of primary invader. Occurs only on needles of the year the primary invader would have matured (Darker 1964) (Table 5).

Limacinia alaskensis Sacc. & Scalia Smithsonian Inst. Publ. *1994:* 13-64 (1910).

ANAMORPH: *Hormisciomyces*

Sooty, black mycelium covering leaves. Ascomata superficial or immersed in the black subiculum, black, globose, 100-200 μm diameter, wall of polygonal cells, with pore, appendaged. Asci ellipsoid, sessile or with knob-like stalk, bitunicate, 8-spored, 48-112 × 15-36 μm. Ascospores ellipsoid, 3-septate, slightly constricted at the septa, brown, guttulate, 20-37 × 8-13 μm (Fig. 36).

Phialophores arising from the cells of the subicular hyphae, 1-3-septate, cells barrel-shaped, giving rise to phialides. Conidia minute, globose, hyaline, nonseptate.

HOSTS: *Thuja plicata, Abies* spp., *Pseudotsuga*

DISEASE: "Sooty mould," a black, superficial growth (Barr 1955).

NOTE: Hughes (1974) indicated a complex of species under this name that should be in the genus *Euantennaria.*

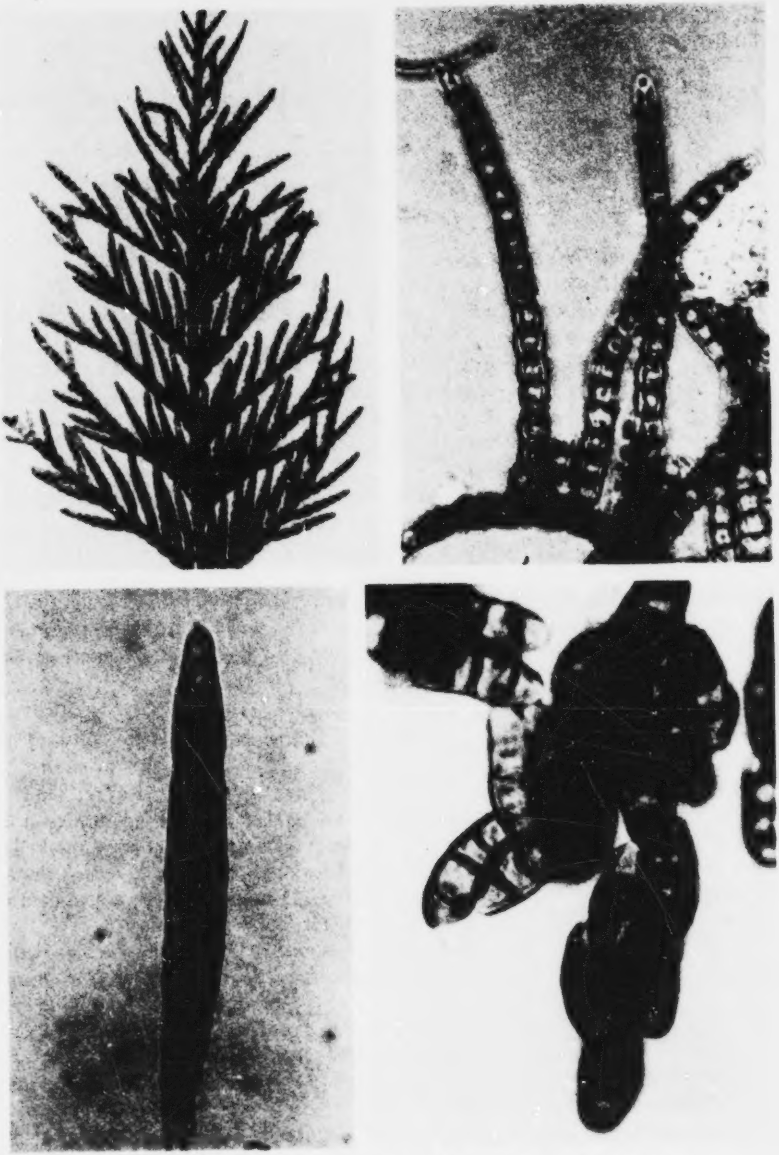


Fig. 36. *Limacinia alaskensis.* Sooty mould mycelium. Conidium. Ascospores.

Linodochium hyalinum (Lib.) Hoehn. Sitzb. K. Akad. Wiss. Wien *118:* 83 (1909).
TELEOMORPH: *Pseudohelotium pineti* (Batsch: Fr.) Fckl.

Sporodochia cream to yellowish, gelatinous when moist, hard when dry, separate to confluent, flat, or rarely pulvinate, round to oval with irregular margin, up to 1.2 mm diameter, tissues of hyaline *textura angularis* grading into *textura porrecta*, more or less gelatinized, hypostromata in stomata of host. Conidiophores hyaline, irregularly branched, septate, smooth, arising from upper cells of sporodochium, 4-20 × 2-3 μm. Conidiogenous cells sympodially proliferating, occasionally annellidic, integrated, cylindrical, terminal, 6-14 × 2 μm. Conidia holoblastic, hyaline, filiform, subulate, straight or slightly curved, 2-4-septate, base truncate, apex acute, 36-88 × 1.5 μm (Fig. 36a).

Apothecia superficial, whitish, up to 1 mm diameter, short-stipitate. Asci cylindric, J+, 70 × 9 μm. Ascospores needle-like, 3-septate, hyaline, 30-40 × 2 μm.

HOST: *Pinus monticola*
DISEASE: Associated with needle blight.

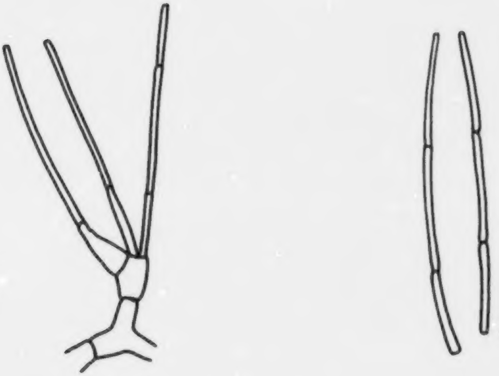


Fig. 36a. *Linodochium hyalinum*. Conidioma and conidia (after Sutton).

NOTES: Recently re-described by Dyko and Sutton (1979).
Soaking needles in water helps to make sporodochia more visible. The teleomorph was connected recently by Minter and Holubova-Jechova (1981) on the basis of cultural work by Gremmen (1960).

Linospora tetraspora G.E. Thompson Can. J. Res. C, *17:* 236 (1939).
ANAMORPH: *Melasmia*-like

Perithecia immersed in stromatized leaf tissue, globose to pyriform, single, 175-270 × 110-175 μm; beak lateral, curved, exserted; covered by a black clypeus. Stromatic tissues are prosenchymatous mixed with host cells; clypeus is parenchymatous, epiphyllous. Asci cylindric, 4-spored, 175-230 × 6-9 μm. Ascospores filiform, hyaline, straight or curved, 5-8-septate, 155-200 × 1-2 μm.

Acervuli epiphyllous, intraepidermal, round or irregular, 125-250 μm diameter. Conidiophores hyaline, 9-13 × 2-3 μm. Conidia (spermatia?) globose, hyaline, nonseptate, 2.5-3 μm diameter.

HOSTS: *Populus trichocarpa*, *P. balsamifera*

DISEASE: Leaf blight, spreads along veins to form irregular lesions; may cover entire leaf (Fig. 36b).

Lirula abietis-concoloris (Mayr ex Dearn.) Darker Can. J. Bot. *45:* 1421 (1967).
SYNONYM: *Hypodermella abietis-concoloris* (Mayr) Dearn.

Hysterothecia mostly hypophyllous, usually nervisequious, black or with bluish-black lustre, continuous along full or part length of needle, 0.5-1.0 mm wide, intraepidermal in center, subepidermal at sides, basal layer hyaline plectenchyma, 15-25 μm thick, covering layer dark pseudoparenchyma, 60-120 μm thick. Asci

Fig. 36b. ***Linospora tetraspora.*** **Leaf blight of poplar.**

clavate, 8-spored, 150-180 × 16-20 μm. Ascospores clavate, hyaline, nonseptate, 70-104 × 4-5 μm, with thin gelatinous sheath. Paraphyses simple, filiform, 135 × 1 μm, conspicuous (Fig. 4).

Pycnidia epiphyllous, continuous or interrupted in groove of needle, or in double interrupted rows, brown to light brown after spore discharge, up to 0.2 mm wide. Conidia rod-like, hyaline, 4-6 × 1 μm.

HOSTS: *Abies amabilis*, *A. grandis*, *A. lasiocarpa*

DISEASE: Needle blight

NOTES: Fruits on 1+ to several-year-old needles. Often followed by the secondary invader *Nothophacidium phyllophilum* that causes a bluish mottling, and by *Stegopezizella balsameae*. *Phaeocryptopus nudus* often colonizes the killed needles.

Lirula punctata (Darker) Darker also occurs on the balsam firs but the asci are 4-spored with rudiments of four additional ascospores; otherwise it is quite similar to *L. abietis-concoloris* (Fig. 37).

Scharpf *et al.* (1970) reported ***L. nervisequia*** (DC.: Fr.) Darker var. *conspicua* Darker on *Abies bracteata* in California with ascospores 40-65 × 2.5-3.5 μm.

Lirula macrospora (Hartig) Darker Can. J. Bot. *45:* 1422 (1967).

SYNONYM: *Lophodermium macrosporum* (Hartig) Rehm

ANAMORPH: *Hypodermina hartigii* Hilitzer

Hysterothecia amphigenous, length varying up to full length of needle, 0.45-0.56 mm wide, shiny black, lips conspicuous, intraepidermal, basal layer of hyaline plectenchyma, 25-30 μm thick, covering layer of dark pseudoparenchyma and epidermis, 55-68 μm thick. Asci clavate-cylindric, tip abruptly tapered, 100-132(180) × 14-16 μm, 8-spored. Ascospores clavate, hyaline, nonseptate, with gelatinous sheath 3-4 μm thick, 56-68(125) × 2.5-3.0 μm. Paraphyses simple, filiform, swollen at the tips, 120 × 1.5-2.0 μm (Figs. 3, 37).

Pycnidia concolorous with leaf surface, conspicuous, applanate.

HOSTS: *Picea* spp.

DISEASE: Needle blight. Considered the most damaging of spruce needle blights. Infected needles are not cast.

NOTES: Another species on spruce, and that occurs often with *L. macrospora*, is ***L. brevispora*** Ziller. This species has smaller asci (80-100 × 11-15 μm) and smaller ascospores (25-35 × 3-3.5 μm) but otherwise resembles *L. macrospora* (Ziller 1969b). Rare. (Fig. 37).

Lirula macrospora has a two-year life cycle although the anamorph appears one-year after infection.

Lophodermella Hoehn. Ber. Deutsch. Bot. Gesell. *35:* 247 (1917).

Hysterothecia concolorous with needle surface, elliptical, short to elongate, subhypodermal, circular in cross-section. Hymenium cupulate; subhymenium thin. Asci clavate. Paraphyses simple, filiform. Ascospores clavate, nonseptate, hyaline, with gelatinous sheath. Pycnidia, if present, small, flask-like (Figs. 3,4, 37a).

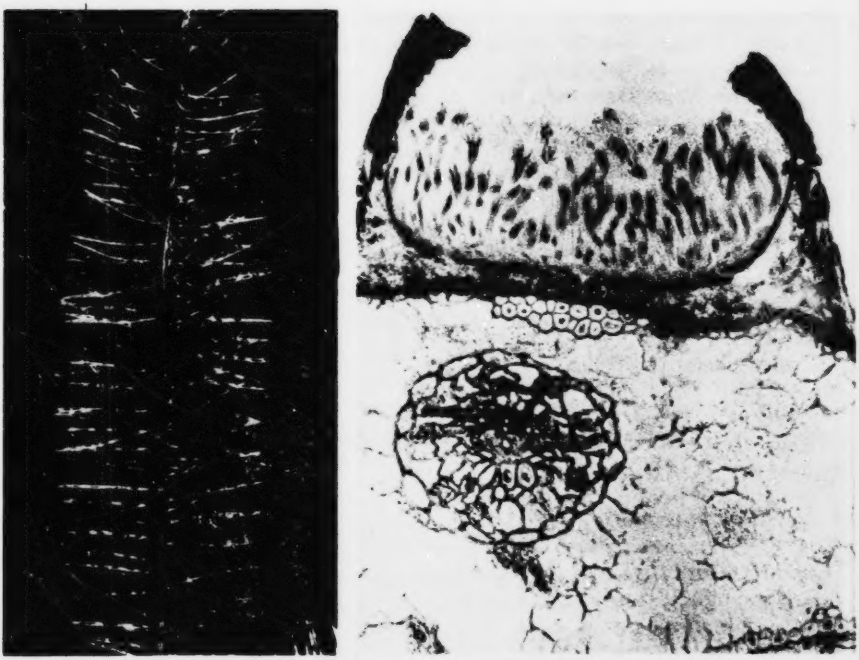


Fig. 37. *Lirula macrospora.* Ascomata on spruce needles. Ascoma, vertical section. *Lirula brevispora.* Asci and spores. *L. punctata.* Anamorph on balsam fir needles.

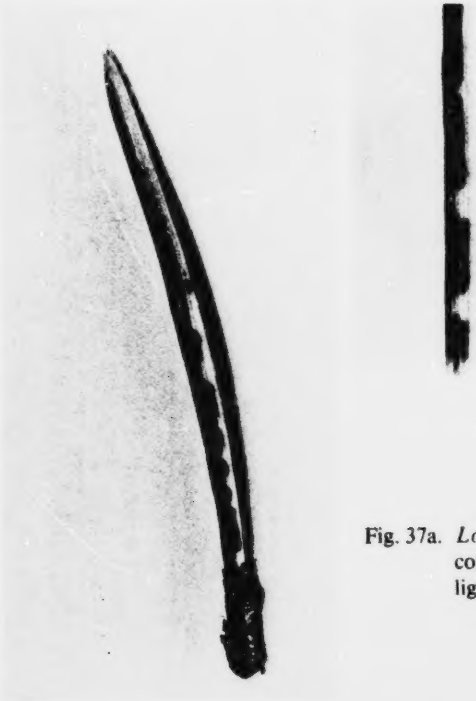


Fig. 37a. *Lophodermella montivaga.* Ascomata on pine needles. Note light-colored slits.

NOTES: *Lophodermella* is represented by seven species occurring only on *Pinus* (Table 2). *Lophodermella concolor* is subject to secondary invaders *Hemiphacidium* and *Hendersonia* (q.v.) that prevent development of ascomata. *Lophodermella* has ascospores similar to *Davisomycella*, but is distinguished by its concolorous, subhypodermal ascomata.

Lophodermella concolor is the most important species in the southern half of British Columbia with a one-year life cycle; needles are cast in midsummer after sporulation of the fungus. *Lophodermella montivaga* is the most important species in northern British Columbia and the Yukon. Both fungi attack needles of the current year only.

The disease may be controlled with Bordeaux Mixture applied to needles when half-developed and when growth stops.

Lophodermium Chev. Flor. Gen. Paris *1:*435 (1826).

Ascomata ellipsoid, blackish, immersed and then erumpent, covered with a clypeus that splits at maturity to reveal the hymenium; zone of the split may be lined with lip cells that may be colored. Asci clavate to cylindric, stalked, apical pore not

Table 2. *Lophodermella* species (Darker 1967)

Species	Hysterothecia	Special Characteristics	Asci	Ascospores	Age of needles	Hosts
L. arcuata (Darker) Darker	0.4-3.1 × 0.2-0.5 mm concolorous subhypodermal		110-160 × 14-18 μm clavate	42-50 × 4-6 μm clavate		*Pinus monticola*, *P. lambertiana*, *P. albicaulis*
L. cerina (Darker) Darker	0.6-2.7 × 0.3-0.6 mm concolorous subhypodermal		160-225 × 17-21 μm fusiform	68-78 × 3.5 μm clavate		*Pinus contorta*, *P. ponderosa*
L. concolor (Dearn.) Darker	0.4-0.8 × 0.3-0.4 mm concolorous subhypodermal	- needles red-brown becoming straw-colored - may form shallow depressions - followed by *Hendersonia* and *Hemiphacidium*	120-225 × 15-17 μm subcylindric	45-60 × 4-8 μm clavate		*Pinus contorta*, *P. banksiana*
L. conjuncta (Darker) Darker	0.5-3.75 × 0.2-0.3 mm light brown subhypodermal	- mostly on tips of green needles - ascomata may fuse laterally	110-160 × 15-16 μm cylindric-fusiform	75-90 × 3-3.5 μm filiform-clavate	1 + yrs	*Pinus sylvestris*
L. montivaga Petr.	0.75-8 × 0.3-0.4 mm light brown to concolorous subhypodermal	- very similar to to *L. sulcigena* - slit is light-colored	120-160 × 12-15 μm clavate	40-50 × 3-4 μm clavate	1 + yrs	*Pinus contorta* (Fig. 37a), *P. banksiana*
L. sulcigena (Rostr.) Hoehn.	2-20 × 0.3-0.4 mm concolorous subhypodermal	- very similar to *L. montivaga* - followed by *Hendersonia*	110-140 × 13-15 μm clavate 4-8-spored	27-35 × 4-5 μm clavate	on brown portions of green needles	*Pinus mugo*, *P. sylvestris*, *P. halepensis* (Europe)
L. morbida Staley & Bynum	1-6 mm long concolorous to brown subhypodermal	- occasionally up to 22 mm long	95-162 × 11-14 μm	23-53 × 2.5-3.5 μm clavate		*Pinus ponderosa*, *P. attenuata* (Staley & Bynum 1972)

Table 3. *Lophodermium* species (Darker 1932, Minter 1981) (Figs. 38, 39)

Species	Host Relation	Zone Lines	Ascomata	Asci	Ascospores	Host
L. consociatum Darker	intra-epidermal	—	0.4-0.6 × 0.6-1.7 mm	150-180 × 15-18 µm	95-120 × 2-2.5 µm	*Abies amabilis*
L. decorum Darker	sub-epidermal	—	0.3-0.6 × 0.5-1.2 mm	140-184 × 16-18 µm	55-75 × 3-4 µm	*Abies grandis*, *A. lasiocarpa*
L. juniperi (Grev.) Darker	sub-cuticular	—	0.3-0.4 × 0.5-0.9 mm	110-130 × 15-17 µm	70-90 × 2-3 µm	*Juniperus*
L. lacerum Darker	intra-epidermal	—	0.5-0.75 × 0.3-0.4 mm	100-125 × 12-16 µm	60-80 × 1.5-2.5 µm	*Abies balsamea*, *A. grandis*
L. laricinum Duby	sub-cuticular	—	0.5-0.6 × 0.2-0.4 mm	100-125 × 9-11 µm	80-115 × 1.5-2 µm	*Larix occidentalis*, *L. laricina*, *L. lyallii* (Ziller 1969)
L. nitens Darker	sub-cuticular	black abundant	0.6-0.85 × 0.35-0.5 mm	95-135 × 11-13 µm	80-120 × 2-3 µm	*Pinus flexilis*, *P. albicaulis*, *P. monticola*
L. piceae (Fckl.) Hoehn.	intra-peridermal		0.6-1.9 × 0.4-0.8 mm	110-140 × 10-14 µm	60-95 × 1.5-2 µm	*Picea*, *Abies*
L. pinastri (S. ex H.) Chev.	partly sub-epidermal	black abundant	0.7-1.2 × 0.3-0.7 mm	110-155 × 9-12 µm	70-110 × 2 µm	*Pinus* spp. (2,3 & 5-needle)
L. seditiosum Minter, Staley & Millar	sub-epidermal	absent or brown	0.8-1.6 mm	140-170 × 11-14 µm	90-120 × 2 µm	*Pinus* spp. (2, 3-needle)
L. uncinatum Darker	sub-cuticular		0.5-2.25 × 0.2-0.5 mm	105-135 × 13-15 µm	50-75 × 1.5-2 µm	*Abies amabilis*, *A. lasiocarpa*

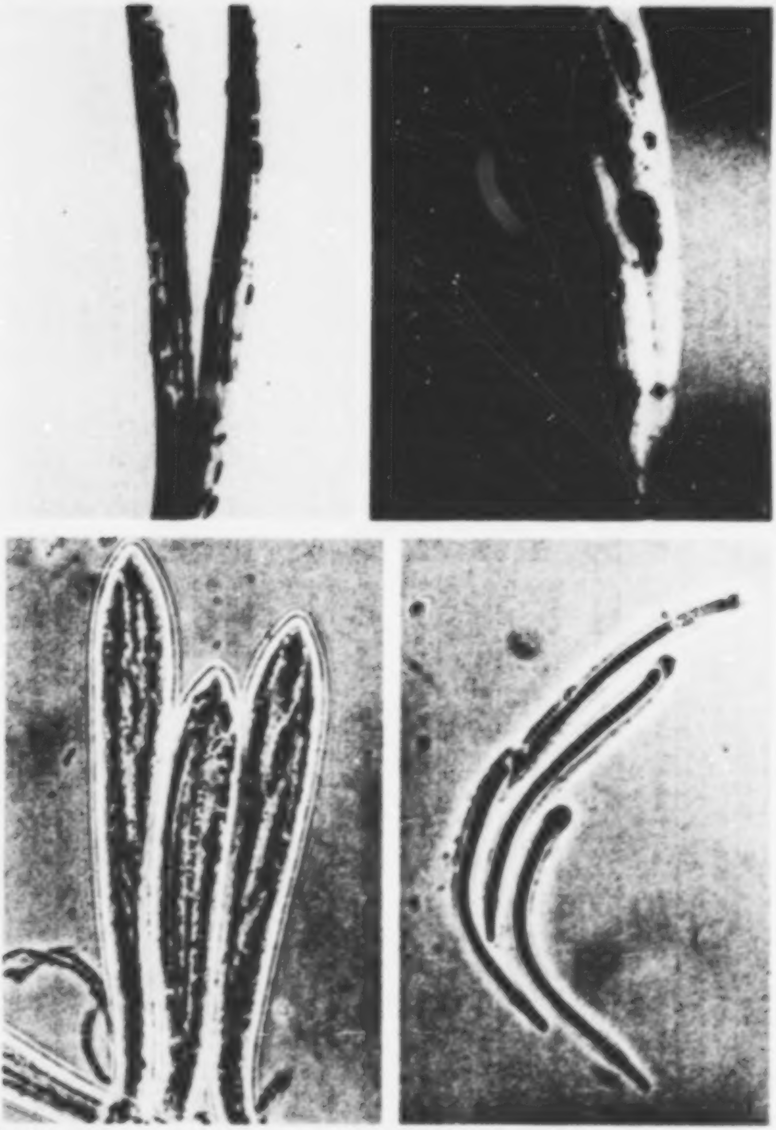


Fig. 38. *Lophodermium pinastri.* Ascomata interspersed with smaller pycnidia on pine needles, showing black zone lines. *Lophodermium* sp. Asci and ascospores.

coloring in iodine, 8-spored. Ascospores hyaline, filiform, nonseptate, with a mucilaginous sheath. Paraphyses filiform, simple, hooked or swollen at the apex (Figs. 3, 4, 38).

Leptostroma anamorph: conidiomata immersed, circular to ellipsoid, dark to concolorous, opening by one or several splits, upper dark wall one cell thick, lower hyaline wall several cells thick. Conidiogenous cells covering lower wall, subulate, holoblastic, sympodial. Conidia rod-like to filiform (Minter 1980).

NOTES: *Lophodermium* is represented by 12 species, on *Pinus*, *Abies*, *Larix*, *Picea*, and *Juniperus* (Table 3). *Lophodermium molitoris* Minter is a subcuticular species on pine that resembles *L. nitens* but differs in having lip cells lining the split (Minter 1980). *Lophodermium baculiferum* Mayr is a rare species on Jeffrey pine with strongly curved tips on paraphyses (Minter 1980), but otherwise it resembles *L. pinastri*.

Two species are fully described.

Lophodermium pinastri (Schrad.: Hook.) Chev. Fl. Gén. Env. Paris *1:* 436 (1826).

ANAMORPH: *Leptostroma pinastri* Desm.

Ascomata amphigenous on needles, black, ellipsoid, 700-1200 μm long, covered by host epidermis on sides, but above epidermis in the center, clypeus not extending to basal wall, opening by single split, lips often red to orange. Asci cylindric, 8-spored, 110-155 × 9-12 μm. Ascospores filiform, nonseptate, 70-110 × 2 μm, in gelatinous sheath. Paraphyses filiform, simple. Zone lines black, abundant in needles (Fig. 38).

Conidiomata subepidermal, 300-400 μm long. Conidia rod-like, 4-6 × 1 μm.

HOSTS: *Pinus*

DISEASE: May inhabit pine needles without producing symptoms. Most reports of damage by *L. pinastri* probably are attributable to *L. seditiosum*.

LIFE CYCLE: Inhabits green needles without producing symptoms. When needles senesce and fall apothecia are produced. Ascospores are released in wet weather (Minter 1981).

Lophodermium seditiosum Minter, Staley & Millar Trans. Br. Mycol. Soc. *71:* 300 (1978).

ANAMORPHS: *Leptostroma rostrupii* Minter (on secondary needles)
Leptostroma austriacum Oud. (on primary needles)

Ascomata amphigenous on needles, grey, surrounded by a black line sometimes, ellipsoid, 800-1500 μm long, totally subepidermal, clypeus opening by a single median split, lips often green or blue. Asci cylindric, 8-spored 140-170 × 11-13 μm. Ascospores filiform, nonseptate, 90-120 × 2 μm, in a gelatinous sheath. Paraphyses filiform, simple, occasionally swollen or hooked. Zone lines in needles absent, or brown and diffuse (Figs. 3, 4).

Conidiomata subepidermal on secondary needles, subcuticular on primary needles. Conidia rod-like, 6-8 × 1 μm.

HOSTS: *Pinus*

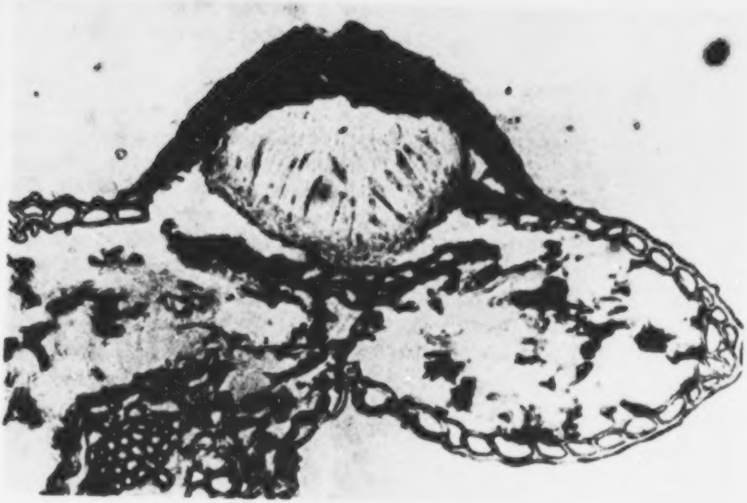


Fig. 39. *Lophodermium laricinum*. Ascoma, vertical section.

DISEASE: Needle cast of pines. Severe attacks may kill young trees. Reports of damage by *L. pinastri* usually can be attributed to *L. seditiosum* (Minter 1981).

LIFE CYCLE: Ascospores are released in late summer and early autumn during wet weather. The ascomata form on two-year-old needles still attached to the tree. The ascomata may also form on needles and cones of trash. Control programs in British Columbia require three spray applications between late July and mid-September (Ormrod 1976).

Lophomerum autumnale (Darker) Magasi Mycologia *58:* 275 (1966).

Ascomata amphigenous, scattered or crowded and frequently confluent, elliptical, shiny black, subcuticular, 0.4-0.8 × 0.3-0.4 mm, covering layer pseudoparenchymatous, 45-50 μm thick. Asci clavate, 8-spored, J-, 110-160 × 12-15 μm. Ascospores filiform, 3-septate at maturity, 85-95 × 1.5-2.0 μm, with thick gelatinous sheath. Paraphyses filiform, septate, recurved at the tips, sometimes branched (Fig. 40).

HOSTS: *Abies lasiocarpa*, *A. amabilis*

NOTES: Secondary invader of needles attacked by *Isthmiella* spp. (Table 5). Fruits during summer and fall on needles of the third growing season. Another species, ***Lophomerum darkeri*** Ouellette, is found occasionally on needles of white spruce; its ascospores are 70-118 × 1-2 μm and up to 5-septate. Its status as a secondary invader to *Lirula macrospora* is suspected.

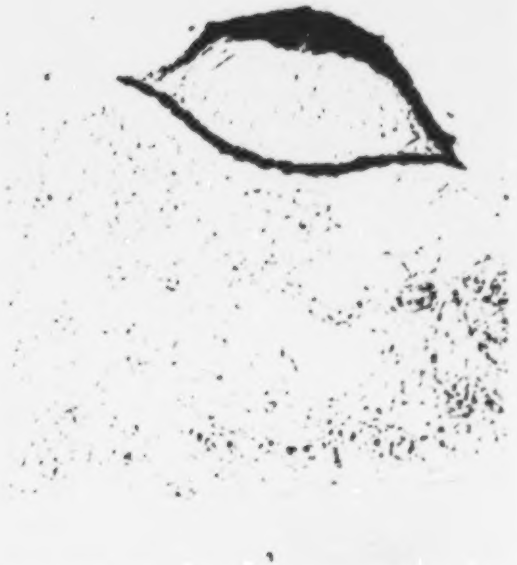


Fig. 40. *Lophomerum autumnale*. Ascoma, vertical section.

Lophophacidium hyperboreum Lagerb. Svensk Bot. Tidsk. *43:* 420 (1949).

Apothecia elongate, from half to full length of the needle, reddish-brown, intrahypodermal, opening lengthwise, 250-500 μm wide, or covering face of needle entirely, up to 250 μm high. Hymenium colorless, subtended by subhymenium up to 40 μm deep, covered by black upper stromatic layer that may not be visible. Asci clavate, 8-spored, pore bluing in iodine, tip rounded, 80-125 × 12-20 μm. Ascospores hyaline, broadly fusiform, nonseptate, 15-25 × 4-8 μm. Paraphyses septate, filiform, simple or branched.

HOSTS: *Picea*

DISEASE: Cause of needle blight of spruce. Smerlis (1966) showed that *L. hyperboreum* attacked *Pinus strobus* and *Abies balsamea* as well as all native spruces in eastern Canada. Chemical control methods were devised (Smerlis 1979).

Marssonina balsamiferae Y. Hiratsuka Mycotaxon *19:* 133 (1984).

Acervuli hypophyllous, subcuticular on brown spots up to 5 mm diameter, and often confluent. Conidiophores simple, phialidic. Conidia hyaline, lunate, 1-septate, upper cell larger with pointed end, lower smaller cell with flat basal scar, 18-21 × 4.5-5.5 μm.

HOST: *Populus balsamifera*
DISEASE: Leaf spot (Hiratsuka 1984).

Marssonina brunnea (Ell. & Ev.) Magn. Hedwigia *45:*89 (1906).
TELEOMORPH: *Drepanopeziza tremulae* Rimpour

Acervuli amphigenous but mostly hypophyllous, intraepidermal, up to 400 μm diameter, conidia accumulating and lifting host cuticle to form yellow-orange blisters. Conidiogenous cells phialidic, cylindrical and often twisted, 6-13 × 2 μm. Conidia hyaline, granular, obovoid, straight or curved, 1-septate, lower cell smaller, with basal scar, larger cell rounded at apex, 11-21 × 4-7 μm. Microconidia sometimes present, hyaline, ellipsoid, nonseptate, 3-5 × 1-2 μm (Fig. 41).

HOST: *Populus tremuloides*
DISEASE: Leaf spot of aspen. Spots brown, angular, discrete, approximately 1 mm diameter.

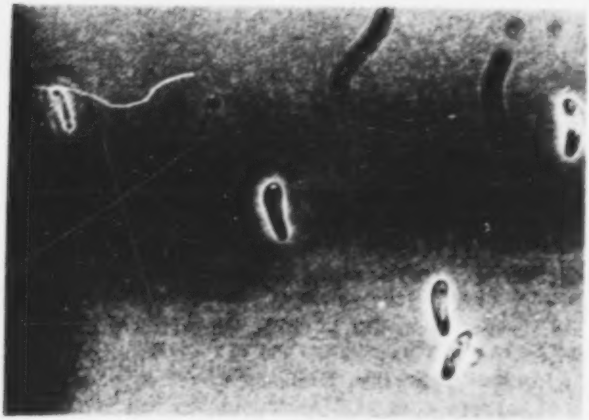


Fig. 41. *Marssonina brunnea*. Conidia.

Marssonina castagnei (Desm. & Mont.) Magn. Hedwigia *45:*89 (1906).
TELEOMORPH: *Drepanopeziza populi-albae* (Kleb.) Nannf.

Acervuli amphigenous but mostly epiphyllous, intraepidermal, up to 400 μm diameter, conidial accumulation lifting host cuticle to form yellowish-white blisters. Conidiogenous cells phialidic, ampulliform, usually twisted, 6-10 × 4-5 μm. Conidia hyaline, obovoid to pyriform, straight or curved, 1-septate, lower cell smaller with flat scar on the base, upper cell rounded, 15-23 × 5-8 μm. Microconidia hyaline, nonseptate, ellipsoid, approximately 3-6 × 2 μm.

HOST: *Populus alba*
DISEASE: Leaf spot of white poplar.

Marssonina populi (Lib.) Magn. Hedwigia *45:* 89 (1906).
TELEOMORPH: *Drepanopeziza populorum* (Desm.) Hoehn.

Acervuli epiphyllous, intraepidermal, 200-400 μm diameter, accumulated conidia lifting host cuticle to form greyish blisters. Conidiogenous cells phialidic, cylindric, 7-12 × 4-5 μm. Conidia hyaline, obovoid to pyriform, curved, 1-septate, lower cell smaller with flat, basal scar, upper cell rounded, 17-27 × 8-13 μm. Microconidia hyaline, nonseptate, obovoid, approximately 3-5 × 2 μm.

HOSTS: *Populus tremuloides, P. trichocarpa*

DISEASE: Leaf spot of poplars. Spots orange-brown, diffuse, irregular, 2-5 mm diameter, coalescing into vein-limited blotches (Harniss and Nelson 1984).

NOTE: The marssoninas on poplars all have a *Drepanopeziza* teleomorph, but these are rarely if ever found in Canada.

The common species causing leaf spot of willow is ***M. kriegeriana*** Magn. with typical conidia measuring 14-18 × 5-7 μm.

Maurodothina farriae Pirozynski & Shoemaker Can. J. Bot. *48:* 1327 (1970).
ANAMORPH: *Pirozynskia farriae* Subram.

Colonies epiphyllous on living needles, effused, black. Mycelium superficial and immersed; superficial hyphae densely interwoven, dark brown, thick-walled, up to 8.5 μm wide, radiating from the ascomata, bearing conidiogenous hyphopodia and conidia. Hyphopodia broadly ellipsoid, producing a solitary conidium through apical pore. Conidia dark brown, tretic, thick-walled, verrucose, becoming 1-septate, 11-18 × 6-8 μm; immersed hyphae forming plectenchymatous, subcuticular stromata.

Ascomata (thyrothecia) roughly circular, crust-like, up to 200 μm diameter, composed of dark brown, radiating cells, opening by stellate cracks. Asci bitunicate, ellipsoid, 8-spored, 25-40 × 12-20 μm, with deliquescing paraphysoids. Ascospores brown, ovoid, 1-septate, 9-13 × 5-6 μm.

HOSTS: *Abies amabilis, A. grandis*

DISEASE: "Black mildew." Conspicuous black colonies on needles that resemble the colonies of *Epipolaeum abietis* shown in Fig. 25.

NOTE: Epiphytic on living needles.

Meloderma desmazierii (Duby) Darker Can. J. Bot. *45:* 1429 (1967).
ANAMORPH: *Leptostroma strobicola* Hilitzer

Hysterothecia elliptical, often in a row, black surrounded by a grayish zone, 0.5-1 × 0.25-0.4 mm, subepidermal but subcuticular near lips; lips bordered by a palisade row of colorless cells; covering layer of dark pseudoparenchyma 30-60 μm thick; basal layer of plectenchyma 8-24 μm thick. Asci cylindrical, round tips, 8-spored, 130-150 × 16-17 μm. Ascospores short-fusiform, hyaline, nonseptate, guttulate, in a gelatinous sheath 4 μm thick, 27-38 × 5 μm. Paraphyses filiform, variously hooked at the tips, sometimes swollen and branched, 125 × 1.5 μm (Fig. 42).

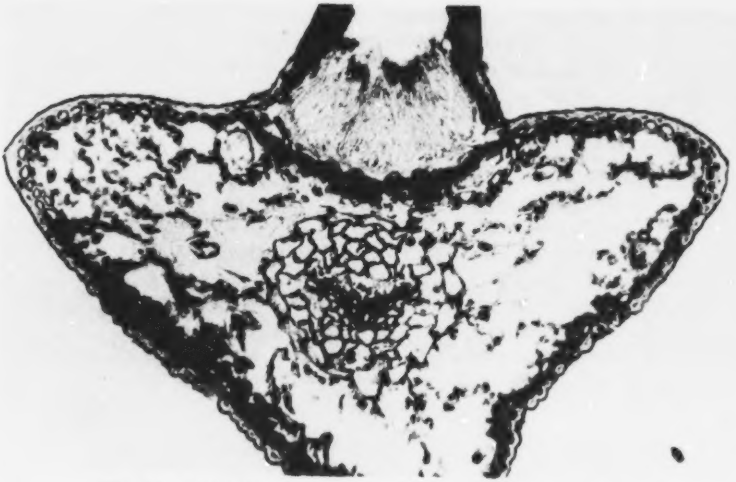


Fig. 42. *Meloderma desmazierii.* Ascoma, vertical section.

Pycnidia simple, flat, no ostiole. Conidia 5-8 × 1 μm.
HOST: *Pinus monticola*
DISEASE: Needle blight. Rare.

Meria laricis Vuillemin Bull. Soc. Sci. Nancy Ser. II. *14:* 15-67 (1896).

Conidiophores originating from substomatal mycelial masses and emerging from the stomates in dense tufts, simple or dichotomously branched, hyaline, septate, frequently curved, up to 45 μm long, 2-3 μm wide. Conidiogenous cells monophialidic, apical or intercalary, indeterminate, + cylindrical, apertures typically produced immediately below the septa on a short sterigma. Conidia hyaline, cylindrical with a median constriction (hence, peanut- or dumb-bell-shaped), nonseptate but becoming 1-septate at germination, 9-13 × 3-4 μm (Fig. 43).

HOSTS: *Larix, Pseudotsuga menziesii*

DISEASE: Needle cast of larch. Needles turn yellow, then brown, and are shed after they die (Dubreuil 1982). The disease developed on Douglas-fir orchard trees under special sprinkler regime and wet spring weather.

NOTES: The fungus is almost invisible on the needle unless stained with cotton blue; it overwinters in the dead needles. Control by fungicides maneb and benomyl applied at bud swell and one month later, then at three-week intervals until weather becomes dry.

Mycosphaerella arbuticola (Peck) Barr Contr. Univ. Mich. Herb. *9:* 587 (1972).

SYNONYM: *Sphaerella arbuticola* Peck

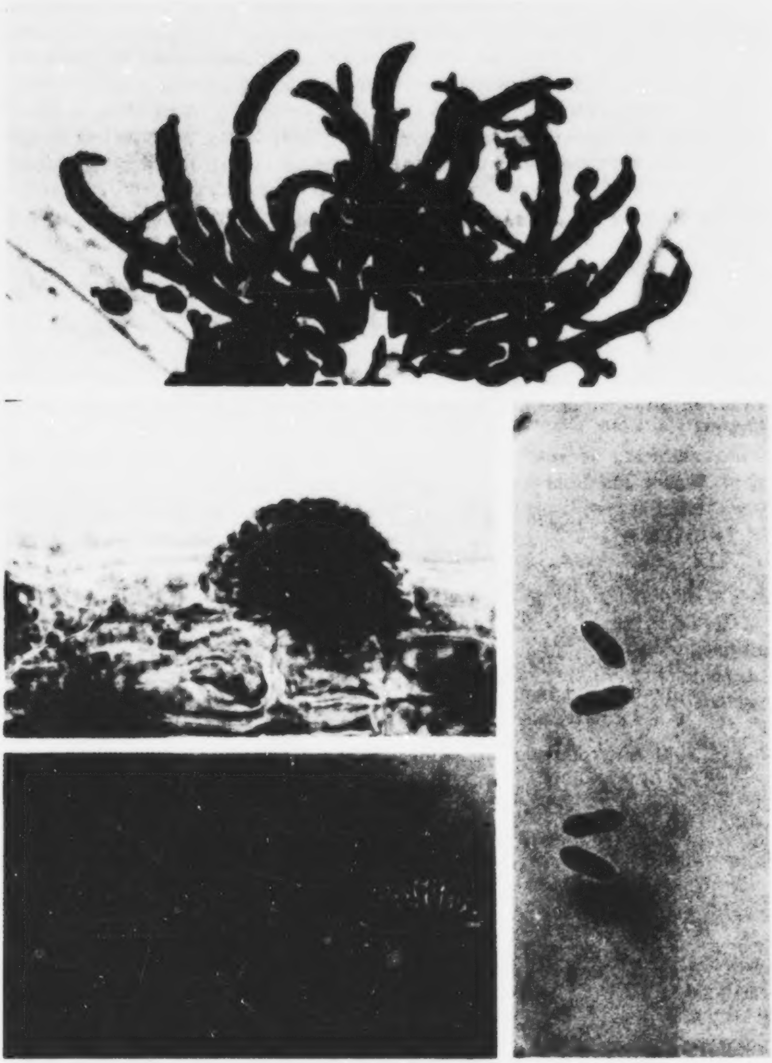


Fig. 43. *Meria laricis.* Sporodochia. Conidiophores and conidia.

Ascomata black, globose, epiphyllous, scattered or grouped, thin-walled, pseudoparenchymatous, 75-128 μm diameter. Asci 40-58 × 9-13 μm, bitunicate. Ascospores 13-19 × 3.5-5 μm, hyaline, elliptic or narrowly obovate, straight or slightly curved, obliquely uniseriate or biseriate in the ascus.

HOST: *Arbutus menziesii*

DISEASE: Leaf spot of *Arbutus.* Spots are brown with dark brown, raised margin, 2-8 mm diameter (Barr 1972).

Mycosphaerella dearnessii Barr Contr. Univ. Mich. Herb. 9: 587 (1972).

SYNONYM: *Scirrhia acicola* (Dearn.) Siggers

ANAMORPH: *Lecanosticta acicola* (Thuem.) Syd.

Ascocarps multiloculate, elliptic, 285-400 × 80-110(300) μm, sometimes confluent to 2.5 mm long, up to 190 μm high, immersed and erumpent; locules 50-80 μm diameter, often in a single row. Asci 35-42 × 6-9 μm, bitunicate. Ascospores hyaline, fusoid, straight to inequilateral, 1-septate, 9-14 × 2.5-3 μm. Paraphyses absent.

Conidiomata elongate, erumpent, locules opening widely, the bases lined with short hyaline conidiophores. Conidia brown, elongate, bent, 3-septate, tapered at apex, blunt at base, rough-walled, 20-28 × 2.5-3 μm. Microconidia rod-like, 2-3 × 1 μm (Fig. 44).

HOSTS: *Pinus contorta, P. banksiana*

DISEASE: Brown spot needle blight of pines. Found in Manitoba (Laut *et al.* 1966). Rare in the west, but very destructive in southeastern U.S.A. A related fungus on *Larix*, ***Mycosphaerella laricina*** Hartig, apparently introduced from Europe, has come west as far as Iowa (Patton and Spear 1983). Conidia are hyaline, 1-4-septate, rounded at the tip, truncate base, 25-45 × 2-4 μm. It causes necrosis of needles and premature defoliation.

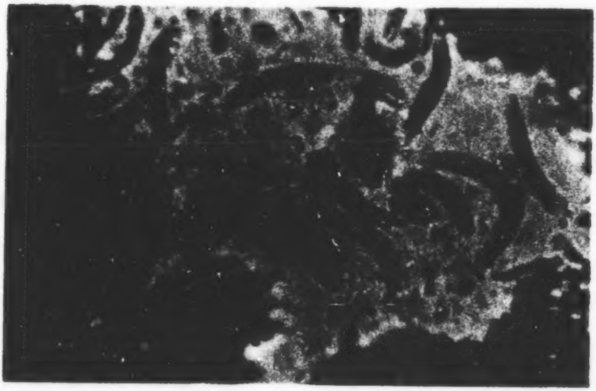


Fig. 44. *Mycosphaerella dearnessii. Lecanosticta* anamorph, conidia.

Mycosphaerella populorum G.E. Thompson Phytopathology *31:* 246 (1941).

ANAMORPH: *Septoria musiva* Peck

Pseudothecia scattered or aggregated, partly erumpent, black, globose, wall pseudoparenchymatous, papillate, 64-106 μm diameter. Asci bitunicate, cylindric-clavate, fasciculate, 8-spored, 54-70 × 13-16 μm. Ascospores hyaline, ellipsoid, 1-septate, slightly constricted at the septum, 16-28 × 4-6 μm. Paraphyses absent.

Pycnidia immersed, globose to subglobose, ostiolate, 48-128 μm diameter. Conidia cylindric, straight or curved, hyaline, 1-4-septate, 28-54 × 4 μm. In humid conditions, conidia ooze out in a pink tendril.

HOSTS: *Populus* spp.

DISEASE: Causes cankers and leaf spot of native, exotic and hybrid poplars.

NOTES: Another related species, ***M. populicola*** G.E. Thompson (ANAMORPH: *Septoria populicola* Peck), produces similar diseases in poplars, but is somewhat larger in all respects: pseudothecia 96-160 μm diameter; asci 64-90 × 13-16 μm; ascospores 22-32 × 6 μm; conidia 45-80 × 3.5-4.5 μm (Bier 1939; Zalasky 1978). Control methods of poplar leaf spots in nurseries were outlined by Carlson (1972).

Naemacyclus minor Butin Eur. J. For. Path. *3:* 160 (1975).

ANAMORPH: *Phomopsis*-like

Ascomata concolorous with the needle, elliptical, 200-600 μm long, subhypodermal, opening by a single longitudinal split to produce two flaps of leaf tissue and expose the white hymenium. Asci cylindric, J-, 8-spored, 80-120 × 10-12 μm. Ascospores hyaline, filiform, with two septa about 8 μm apart near the middle, bent in the middle, 65-100 × 2.5-3 μm. Paraphyses filiform, branched toward the apex. Broad, reddish-brown zone lines may occur across the needle at maturity.

Pycnidia immersed, globose, walls of hyaline pseudoparenchyma, 150-250 μm diameter. Conidiogenous cells subulate, phialidic. Conidia bacillar, 6-10 × 1 μm.

HOST: *Pinus contorta*

DISEASE: Needle cast of pines.

NOTES: Butin (1975) showed that *N. minor* should be recognized as distinct from *N. niveus* on the basis of smaller ascomata, ascospores and conidia. *Naemacyclus minor* is also considered to be the more virulent pathogen (Millar and Minter 1980). See note under *N. niveus.*

LIFE CYCLE: Ascospores may be released from mid-summer to the following spring from fallen or attached needles. Needles of any age may be infected. Symptoms first appear a year or more later as a light green spot developing into a yellow band with zone lines interspersed. Ascomata develop in fall or spring and are preceded by pycnidia (Peterson 1981).

Naemacyclus niveus (Pers.: Fr.) Sacc. Bot. Zentralblatt *18:* 251 (1884).

ANAMORPH: *Phomopsis*-like

Ascomata concolorous with needle, elliptical, up to 1 mm long, opening by a

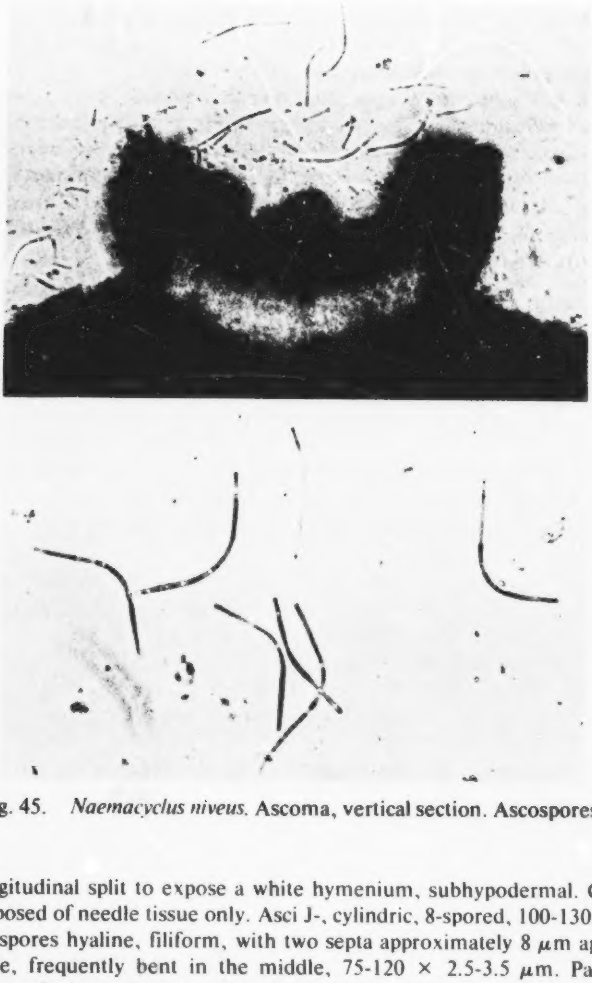


Fig. 45. *Naemacyclus niveus.* Ascoma, vertical section. Ascospores.

single longitudinal split to expose a white hymenium, subhypodermal. Covering flaps composed of needle tissue only. Asci J-, cylindric, 8-spored, 100-130 × 11-13 μm. Ascospores hyaline, filiform, with two septa approximately 8 μm apart near the middle, frequently bent in the middle, 75-120 × 2.5-3.5 μm. Paraphyses filiform, branched near the apex. Broad, reddish-brown zone lines may be present in the needle (Fig. 45).

Pycnidia immersed, globose, walls of hyaline parenchyma, 100-220 μm diam. Conidiogenous cells subulate, phialidic. Conidia curved, elongate, 12-16 × 1 μm.

HOSTS: *Pinus contorta, P. radiata, P. flexilis*

DISEASE: A weak parasite of pine needles.

NOTE: The revision of DiCosmo *et al.* (1983) has placed both species of *Naemacyclus* in the new genus *Cyclaneusma* of the Rhytismataceae (Hypodermataceae), the ascospores having gelatinous caps.

Nothophacidium phyllophilum (Peck) Smerlis Can. J. Bot. *44:* 563 (1966).

Apothecia sessile, cupulate, hymenium colorless, subepidermal, becoming erumpent, epidermis often remaining as a lid, excipulum of dark brown pseudoparenchyma with hair-like cells on the margins, 0.5-0.8 mm wide, 0.25 mm high, scattered or in rows up to 5 mm long. Asci cylindric or slightly clavate, very short stipe, 8-spored, thickened at the rounded apex, pore not staining in iodine, 60-75 × 9-14 μm. Paraphyses filiform, slightly swollen at the tips, longer than the asci. Ascospores oval to broadly ellipsoid, hyaline or pale brown, nonseptate, 5.5-8.5 × 4.5-6.5 μm.

HOST: *Abies lasiocarpa*

DISEASE: Secondary invader of needles parasitized by *Lirula abietis-concoloris* (Table 5). Considered a snow-mould by Reid and Cain (1962a), Smerlis (1966) gave evidence that it was not a primary pathogen. Characteristically causes blue mottling of needles.

Pestalotiopsis funerea (Desm.) Steyaert Bull. Jard. Bot. Brux. *19:* 340 (1949).

Acervuli lenticular to globose, rupturing the epidermis, 1-2 mm diameter Conidiogenous cells annellidic, formed from upper cells of acervular stroma, cylindric to obovoid, 5-15 × 2-4 μm. Conidia fusiform, straight or curved, 4-euseptate, slightly constricted at the septa, three median cells olive-brown, apical and basal cells hyaline, 22-32 × 7-13 μm; with 2-6 apical appendages hyaline, 5-28 μm long; basal appendage single, endogenous, hyaline, straight, 2-11 μm long (Fig. 46).

HOSTS: Cupressaceae

DISEASE: Causes stem and leaf blight of conifers, especially Cupressaceae. Also saprophytic on dead material. Often in association with other fungi in dis-

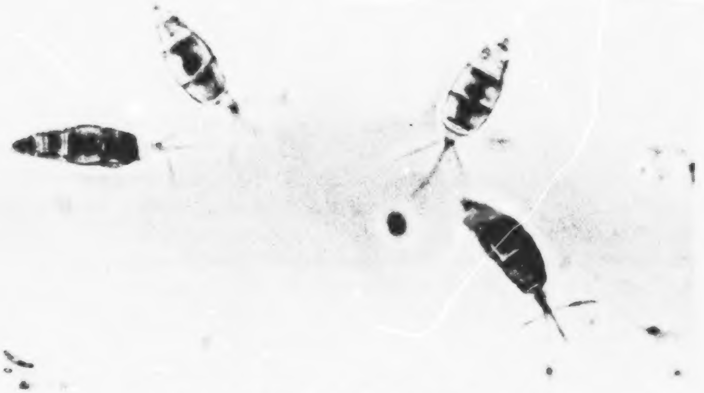


Fig. 46. *Pestalotiopsis funerea.* Conidia.

eased trees. Not considered a serious pathogen in good growing conditions.

NOTES: The genus *Pestalotiopsis* has 4-euseptate conidia, separating it from *Pestalotia* which has 5-distoseptate conidia (Sutton 1969). See note under *Truncatella truncata.*

Phacidium abietis (Dearn.) Reid & Cain Mycologia *54:* 482 (1962).

Apothecia embedded in the hypodermis, erumpent through epidermis at maturity, in series on each side of midrib of lower surface of needle, oval to circular, often with a central papilla; roof black, opening by several irregular teeth; 300-500 µm diameter, 120-225 µm high; hymenium pale yellow, subhymenium white. Asci clavate, long-stalked with a basal foot, tip rounded, pore bluing in iodine, 90-125 × 13-15 µm, 8-spored. Ascospores oval, fusoid or flattened on one side, hyaline, nonseptate, 18-25 × 6-7.5 µm. Paraphyses filiform, nonseptate.

HOSTS: *Pseudotsuga menziesii, Abies lasiocarpa, A. balsamea, A. grandis*

DISEASE: Snow-blight; the fungus invades the foliage while covered with a layer of snow, spreading by a profuse web-like, white mycelium. Chemical control methods were devised (Smerlis 1979).

NOTES: In Europe, the related fungus ***Phacidium infestans*** Karsten causes snow-blight of conifers but this species is unknown in North America.

Phacidium pini-cembrae (Rehm) Terrier is occasionally found on Douglas-fir. This species has two sizes of asci, the larger being 8-spored, measuring 85-125 × 8-12 µm and the smaller being 40-70 × 8-12 µm and 1-5-spored. Ascospores in the smaller asci are occasionally 1-3-septate.

Phacidium dearnessii DiCosmo, Nag Raj & Kendrick (1983) has been found on needles of western yew with ascospores 6-11 × 3-5 µm. The anamorph is *Apostrasseria robusta* Nag Raj with lunate conidia 5-9 × 3-4 µm (Nag Raj 1983).

Phacidium sherwoodiae DiCosmo, Nag Raj & Kendrick (1983) has been reported on dead leaves of western red cedar; ascospores are subfusiform, 9-11 × 3-4 µm. The anamorph is *Ceuthospora* with rod-shaped, appendaged conidia (DiCosmo *et al.* 1983) that I have found on needles of Douglas-fir and Noble fir (Fig. 47).

Phaeocryptopus gaeumannii (Rohde) Petrak Ann. Mycol. *36:* 22 (1938).

SYNONYM: *Adelopus gaeumanni* Rohde

Pseudothecia black, globose, smooth, developing from a knot of dark cells within the stoma of the leaf and becoming superficial, wall of dark, subglobose cells one or two layers thick, 50-80 µm diameter. Asci bitunicate, clavate or slightly ventricose, 8-spored, 30-40 × 8-15 µm. Ascospores slightly clavate, hyaline to pale yellow, 10-15 × 3.5-5 µm, close to centrally 1-septate (Fig. 48).

HOST: *Pseudotsuga menziesii*

DISEASE: Causes the "Swiss Needle Cast" of Douglas-fir. Locally or generally severe at the coast and interior when climatic conditions favor spread (Hood 1982). Damage to Christmas tree plantations by needle discolora-

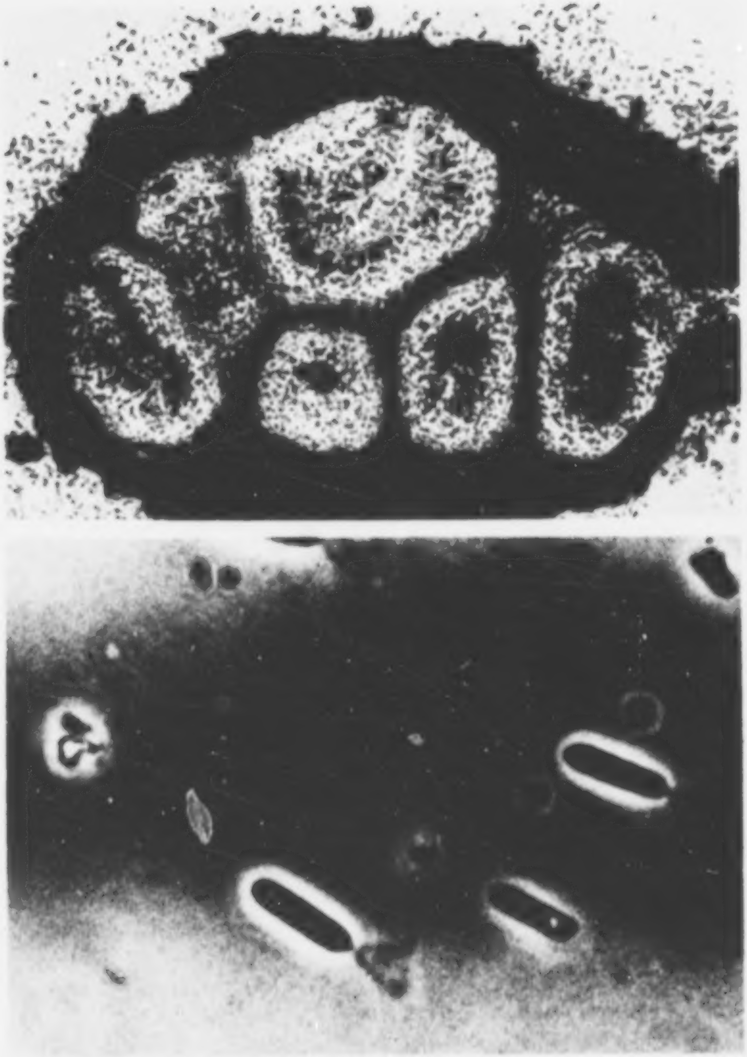


Fig. 47. *Phacidium sherwoodiae. Ceuthospora* anamorph. Conidia.

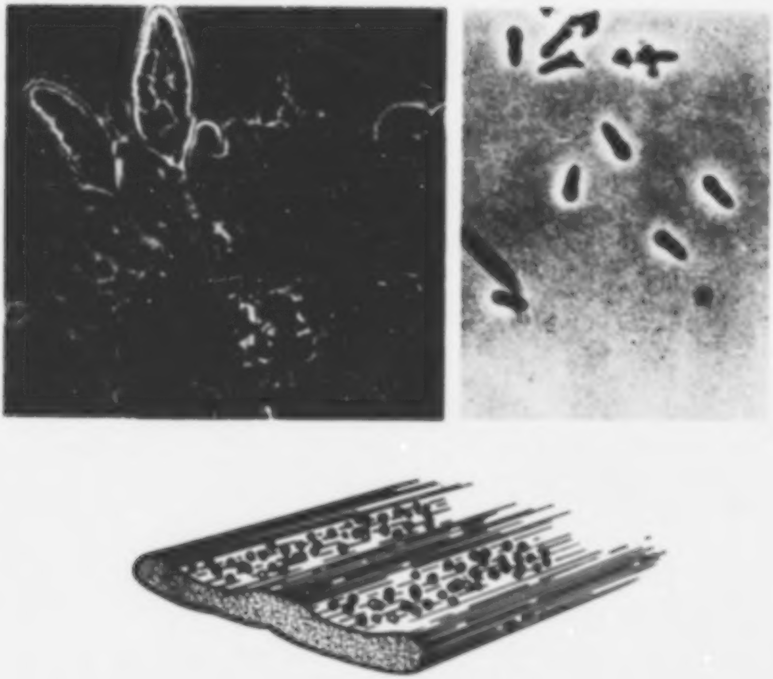


Fig. 48. *Phaeocryptopus gaeumannii.* Ascomata on Douglas-fir needle (after Butin).

tion to yellow or brown; loss of one- and two-year-old needles in summer.

NOTES: Hood (1979, 1982) has worked on infection, control and life cycle of *P. gaeumannii* in New Zealand and Canada; Chastagner and Byther (1983 a, b) studied infection and control in Washington state, U.S.A. Ascospores mature in April and May on one-year-old needles.

Phaeocryptopus nudus (Peck) Petrak   Ann. Mycol. *36*: 15 (1938).

SYNONYM: *Adelopus nudus* (Peck) Theiss.

Pseudothecia black, globose, smooth, superficial on the needle, attached by a peg of tissue inserted in the stoma and continuous with the intercellular hyphae, walls of dark, subglobose cells, one or two layers thick, opening by a small pore, 80-155 μm diameter. Asci bitunicate, clavate to ventricose, 32-56 × 11-15 μm, surrounded by deliquescing paraphysoids, 8-spored. Ascospores slightly clavate, hyaline to pale brown, near centrally 1-septate, 10-15 × 4-5 μm, biseriate.

HOSTS: *Abies amabilis*, *A. balsamea*, *A. lasiocarpa*, *Picea sitchensis*
DISEASE: Mildly parasitic or saprophytic. Causes browning of needles. Often colonizes needles killed by *Lirula abietis-concoloris.*

Phaeoseptoria contortae Parmelee & Hiratsuka Can. J. Bot. *48:* 1003 (1970).

Pycnidia immersed, black, globose, amphigenous, 150-200 μm diameter with short neck. Conidiophores short, simple, lining interior wall of pycnidium. Conidiogenous cells acrogenous. Conidia fusoid to falcate, pale brown, 3-4-septate, 25-45 × 3-4 μm, oozing out in brown tendrils (Fig. 49).

HOST: *Pinus contorta*

DISEASE: Appears to cause blight of one-year-old pine needles, but pathogenicity not proved. In the type specimen associated with *Davisomycella ampla.*

NOTE: ***Periperidium acicola*** Darker has conidia of similar form but is found on black spruce needles in Ontario. Its teleomorph is the phacidiaceous discomycete, *Micraspis acicola* (Darker 1963).

Phoma glomerata (Corda) Wr. & Hochapf. Z. Parasit Kde. *8:* 592 (1936).

Pycnidia globose to pyriform or elongated, with long necks and often with more than one ostiole, dark brown, 50-300 μm in diameter; wall of dark pseudopa-

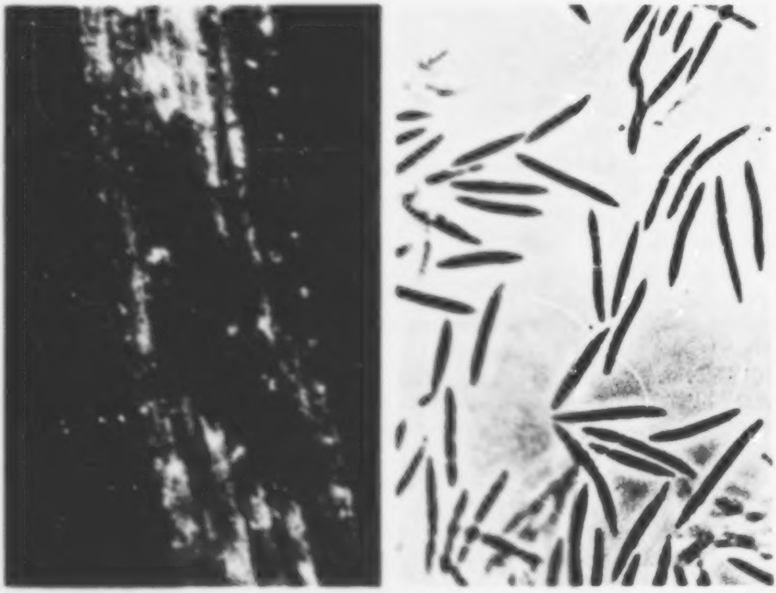


Fig. 49. *Phaeoseptoria contortae.* Conidiomata on leaves. Conidia.

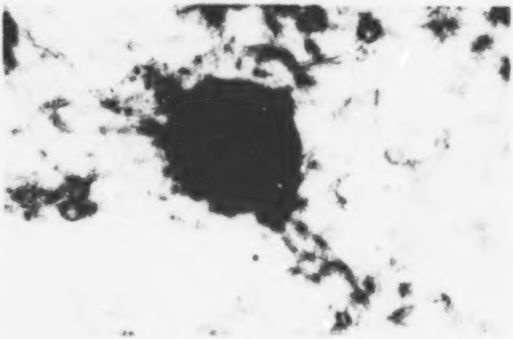


Fig. 50. *Phoma* sp. Pycnidium, top view.

renchyma outside, of subhyaline, thin-walled cells inside, bearing conidiophores. Conidia unicellular, rarely 1-septate, ellipsoid to oblong or obovate, guttulate, subhyaline, smooth, pale olive-brown with minutely roughened wall, 5-10 × 2.5-4 μm.

Dictyochlamydospores brown, in chains sometimes branched, irregularly ovate, up to 9 transverse septa and 3-6 longitudinal septa (produced in culture).

HOSTS: Conifers

DISEASE: Causes damping-off of conifer seedlings.

NOTES: *Phoma pomorum* Thuem. (= *P. prunicola* (Opiz.) Wr. & Hochapf.) is also found on conifer seedlings, but this species produces chlamydospores terminally and singly, not in chains (Fig. 50).

Phomopsis lokoyae Hahn Mycologia *25:* 369 (1933).

TELEOMORPH: *Diaporthe lokoyae* Funk

Pycnidia erumpent, black, lenticular to subglobose, 300-600 μm diameter, 200-300 μm high. Conidiophores lining the single locule, flexuous, subulate, 5-20 μm long; conidiogenous cells phialidic. Conidia of 2 types: A-spores hyaline, elliptic-fusoid (irregular), nonseptate, biguttulate, 6-10 × 2-4 μm; B-spores hyaline, elongate-fusiform, nonseptate, minutely guttulate, 10-12 × 1.5-2.5 μm (Fig. 51).

HOSTS: *Pseudotsuga menziesii*, occasionally on *Tsuga heterophylla* and *Thuja plicata*

DISEASE: Top-killing of nursery seedlings.

NOTES: Only pycnidia are found on needles. A weak parasite, ***Phomopsis occulta*** Trav., occurs on needles of nursery seedlings of many conifers; A-conidia are ellipsoid, 6-9 × 2-3 μm, B-conidia filiform, curved, 20-30 × 1 μm; some conidia may be intermediate in shape and size (Fig. 52).

Phomopsis conorum (Sacc.) Died. has also been found on needles of blighted conifer seedlings. It is distinguished by its relatively large A-conidia (6-15 × 3-5 μm) and its strongly curved (horseshoe-shaped) B-conidia that measure 10-35 × 1 μm.

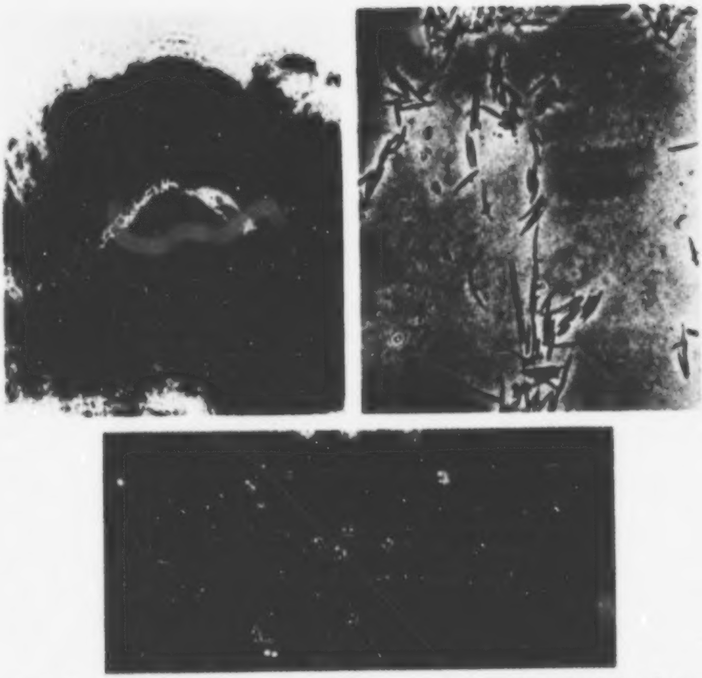


Fig. 51. *Phomopsis lokoyae*. Pycnidium, vertical section. Conidia of two types.

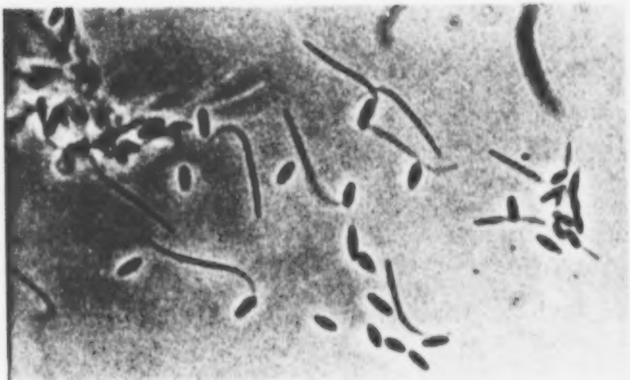


Fig. 52. *Phomopsis occulta*. Conidia of two types.

Phyllactinia guttata (Fr.) Lév. Ann. Sci. Nat. Bot. III, *15:* 144 (1851).
ANAMORPH: *Oidium*

Perithecia superficial, subglobose, black, up to 175 μm diameter, nonostiolate, bearing around the equator a ring of 5-18 stiff, pointed, hyaline setae, 200-600 μm long, with a subglobose swelling at the base; the apex of the perithecium bears a tuft of short setae. Asci numbering up to 45, ovoid, more or less stalked, 60-100 × 25-40 μm, usually 2-spored. Ascospores ovoid, 30-40 × 16-25 μm.

Conidiophores 1-4-septate, 100-500 × 8-9 μm. Conidia clavate or rhomboid, 75 × 25 μm.

HOSTS: *Alnus, Amelanchier, Betula, Cornus*

DISEASE: Powdery mildew of leaves.

Phyllosticta cornicola (DC.) Rabenh. Kl. Herb. Myc. No. 454 (1855).

Pycnidia epiphyllous, sparse, punctiform, lenticular, with apical pore, 150-200 μm diameter. Conidiophores subulate, simple or branched, phialidic. Conidia hyaline, nonseptate, ellipsoid-fusiform, biguttulate, 7-9 × 3-4 μm.

HOST: *Cornus nuttallii*

DISEASE: Leaf blotch of flowering dogwood (Fig. 27). The blotches are typically brown, wedge-shaped at the leaf tips, less frequently from the edges. Infections occur in spring and may cause early leaf fall, but most trees produce a second set of leaves. *Gloeosporium* "*corni*" has also been linked to leaf blotch (q.v.).

Phyllosticta sp.

Pycnidia black, globose, erumpent, hypophyllous, approximately 150 μm diameter. Conidiogenous cells lining inner wall of pycnidium, awl-shaped, phialidic. Conidia globose, hyaline, thick-walled, 8-10 μm diameter, without appendages (Fig. 52a).

HOST: *Abies grandis*

DISEASE: Needle blight of grand fir in Christmas tree plantations. Tips or segments of needles become bright red. Reported only from Idaho, U.S.A.

Phyllostictina hysterella (Sacc.) Petr. Trans. Brit. Mycol. Soc. *22:* 102 (1938-39).
TELEOMORPH: *Physalospora gregaria* Sacc.

Pycnidia immersed, subgregarious, dark brown, subglobose to ovoid, 185-210 × 140-180 μm, ostiole indistinct, wall of dark brown elongated cells, young pycnidia filled with parenchymatous cells. Conidiophores straight, cylindric, tapered at the tip, 5-11 × 2-3 μm. Conidia in mucilage, oval to elliptical, unicellular, hyaline, filled with granular cytoplasm, 10-16 × 8-10 μm.

HOST: *Taxus brevifolia*

DISEASE: Causes shoot and leaf blight of western yew.

NOTES: The teleomorph has not been found in the range of western yew.

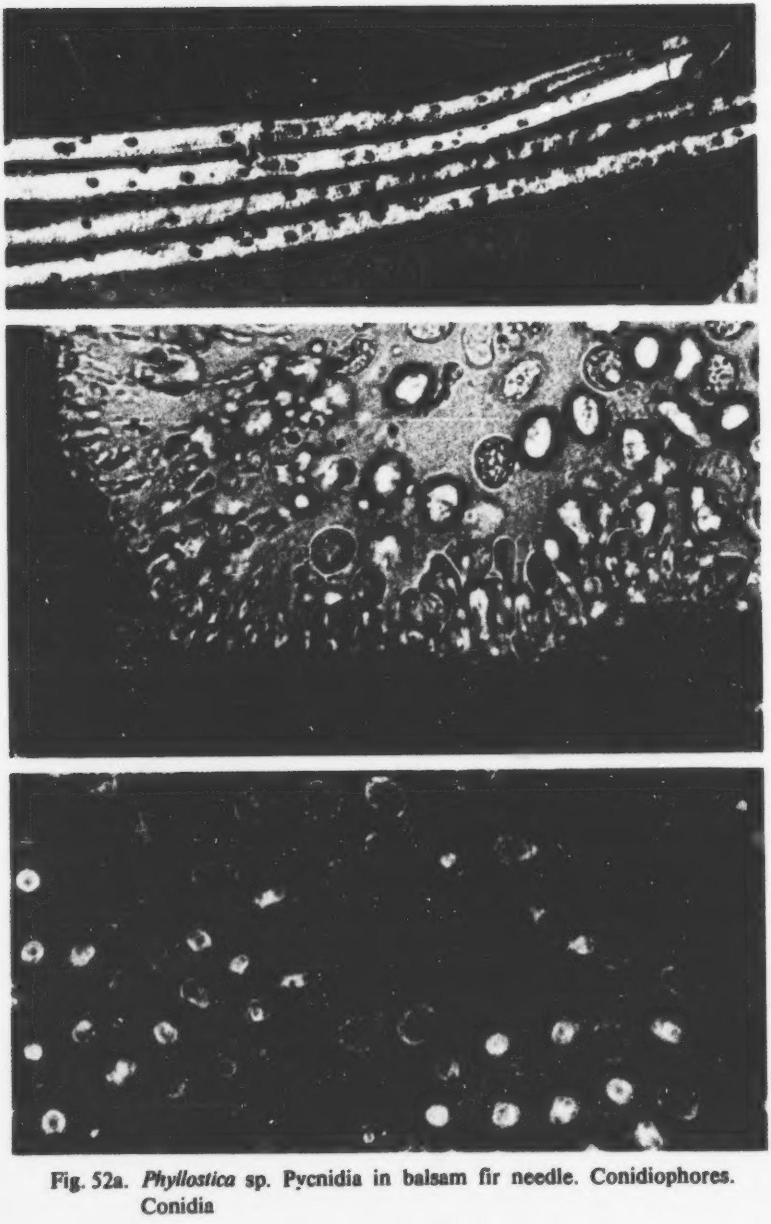


Fig. 52a. *Phyllostica* sp. Pycnidia in balsam fir needle. Conidiophores. Conidia

Pithya cupressina (Fr.) Fckl. Jahrb. Nass. Naturk *23-24:* 317 (1870).

Apothecia bright orange, approx 1 mm diameter, disc flat, short-stalked, excipulum paler orange. Asci 8-spored, 210 × 12 μm. Ascospores uniseriate in the ascus, globose, hyaline, nonseptate, 9-10 μm diameter. Paraphyses cylindrical, slightly enlarged at the tip to 4 μm.

HOSTS: *Thuja, Juniperus*

NOTE: Saprophytic.

Key to *Rhabdocline* (Parker & Reid 1969)

1. Ascus pore lacking, not bluing in iodine (Melzer's Reagent)
   A. Apothecia hypophyllous, rarely epiphyllous; paraphyses filamentous or slightly swollen at tips; sometimes associated with *Rhabdogloeum hypophyllum*.. *R. pseudotsugae* subsp. *pseudotsugae*
   B. Apothecia epiphyllous; paraphyses with swollen tips to 10 μm; on one-year-old needles only; absent from interior dry belt .... *R. pseudotsugae* subsp. *epiphylla*

2. Ascus with pore, bluing in iodine
   A. Ascospores oblong to slightly constricted at the middle; apothecia hypophyllous, on one-year-old or older needles.
      1. Apothecia varying in size and shape; on 1-yr-old and older needles; associated with *Rhabdogloeum pseudotsugae* .... *R. weirii* subsp. *weirii*
      2. Apothecia rectangular, occupying width of needle; on 1-yr-old needles .... *R. weirii* subsp. *oblonga*
   B. Ascospores obovate, 1- or 2-celled, apothecia hypophyllous, on 2-year-old and older needles .... *R. weirii* subsp. *obovata*

Rhabdocline pseudotsugae Syd. Ann. Mycol. *20:* 194 (1922).

ANAMORPH: ? *Rhabdogloeum hypophyllum* Ell. & Gill

Apothecia chiefly hypophyllous orange to red-brown, on one or both sides of needle midrib; erumpent by median splitting of overlying epidermis, or by circumscissile or lateral splitting when apothecia small; hypothecium poorly developed, no epithecial tissue, excipulum of marginal paraphyses only; situated in necrotic spots that are roughly circular, band-like or extending up to entire length of needle, discrete or confluent in the necrotic spots, 0.5-10 × 0.3-0.6 mm. Asci clavate, broadest below apex which is flattened, 8-spored, opening by a pseudooperculum or a bilabiate split of the apex, does not stain with iodine (J-), 120-160 × 16-22 μm. Ascospores at first hyaline and 1-celled, becoming 2-celled with one cell turning dark brown, oblong with obtuse ends, slightly constricted at the middle, 13-19 × 5-8 μm, with a thick, gelatinous sheath. Paraphyses septate, up to 2.5 μm thick, sometimes slightly swollen at the tips, extending beyond the asci to form an epithecium (Fig. 53).

HOST: *Pseudotsuga menziesii*

DISEASE: Needle cast of Douglas-fir. Apothecia mature in May-June on one-

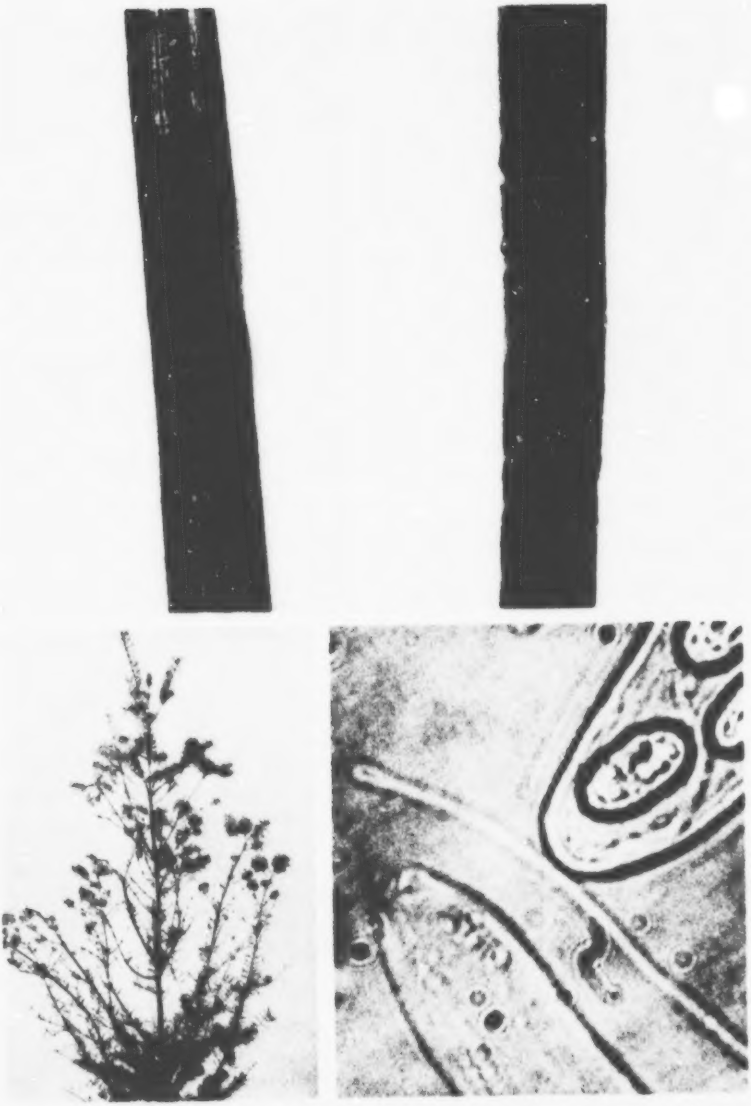


Fig. 53. *Rhabdocline pseudotsugae*. Ascomata in needles, subsp. *pseudotsugae* (left), subsp. *epiphylla* (right). Typical defoliation pattern in young Douglas-fir. Ascus tip showing thin wall and split. (Photos by Parker and Reid).

year-old needles and ascospores infect only current season's needles. There is much variation in susceptibility to this disease. Needles are usually cast right after ascospore discharge (June, July) (Parker 1970).

NOTES: *R. pseudotsugae* subsp. *epiphylla* Parker & Reid is basically similar with J- asci, but differs in that apothecia are chiefly epiphyllous, and less than 4 mm long; asci measure 80-120 × 18-22 μm; ascospores broadly ellipsoid, 14-21 × 6-9 μm; paraphyses swollen at the tips to 10 μm wide and pale brown; occurs on one-year-old needles only. Absent from interior dry-belt of British Columbia.

Chemical control of Rhabdocline needle blight is practical with organic fungicides as well as copper (Morton and Miller 1982).

Rhabdocline weirii Parker & Reid Can. J. Bot. *47:* 1540 (1969).

ANAMORPH: *Rhabdogloeum pseudotsugae* Syd.

Apothecia hypophyllous, orange to red-brown, on one or both sides of needle midrib, erumpent by lateral splitting of overlying epidermis; hypothecium poorly developed, pseudoparenchymatous; excipulum of marginal paraphysis-like elements; situated in necrotic bands of tissue of varying length which may extend across entire width of the needle, irregular, circular or rectangular, 1-10 mm long, orange to red-brown. Asci clavate, broadest below the flattened apex, 8-spored, opening by a pore, the pore staining blue in iodine (J+), 100-130 × 15-20 μm. Ascospores at first hyaline and 1-celled, becoming 2-celled and one cell turning dark brown, oblong, slightly constricted in the middle, 13-19 × 4-8 μm, with a thick gelatinous sheath. Paraphyses septate, up to 2.5 μm thick, sometimes slightly swollen at the tips (Fig. 54).

Acervuli abundant, scattered, gregarious or confluent, amphigenous, linear, up to 2 mm long, 200-250 μm wide, at first covered, later exposed by the rupture of the epidermis and cuticle. Stroma pseudoparenchymatous, immersed in the substratum, subepidermal, composed of hyaline cells. Conidiogenous cells arising from the upper cells of the stroma, compactly arranged, phialidic, cylindrical to ampulliform, short, hyaline, smooth-walled, with a small collarette, sometimes proliferating percurrently once or twice, 9-20 × 4-6.5 μm. Conidia formed in succession from phialides, solitary, cylindrical or dumb-bell-shaped, unicellular, guttulate, hyaline, smooth-walled, obtuse at the apex, truncate at the base, 14-17 × 4-6 μm, with an apical or subapical, filiform, erect or flexuous, mucoid appendage, 3-5.5 × 1.5-2 μm.

HOST: *Pseudotsuga menziesii*

DISEASE: Needle cast of Douglas-fir.

NOTES: *R. weirii* subsp. *obovata* Parker & Reid is basically similar with J+ asci, but differs in that the ascospores are obovate in shape and it is not associated with a *Rhabdogloeum*; apothecia usually on both sides of midrib, linear; asci 90-145 × 16-20 μm; ascospores obovate, with upper part broader, 16-22 × 6-9 μm; occurs on two-year-old and older needles.

R. weirii subsp. *oblonga* Parker & Reid is very similar to *R. weirii* subsp. *weirii* but is not associated with a *Rhabdogloeum* and apothecia occur chiefly on one-year-old needles. Has not been found in British Columbia.

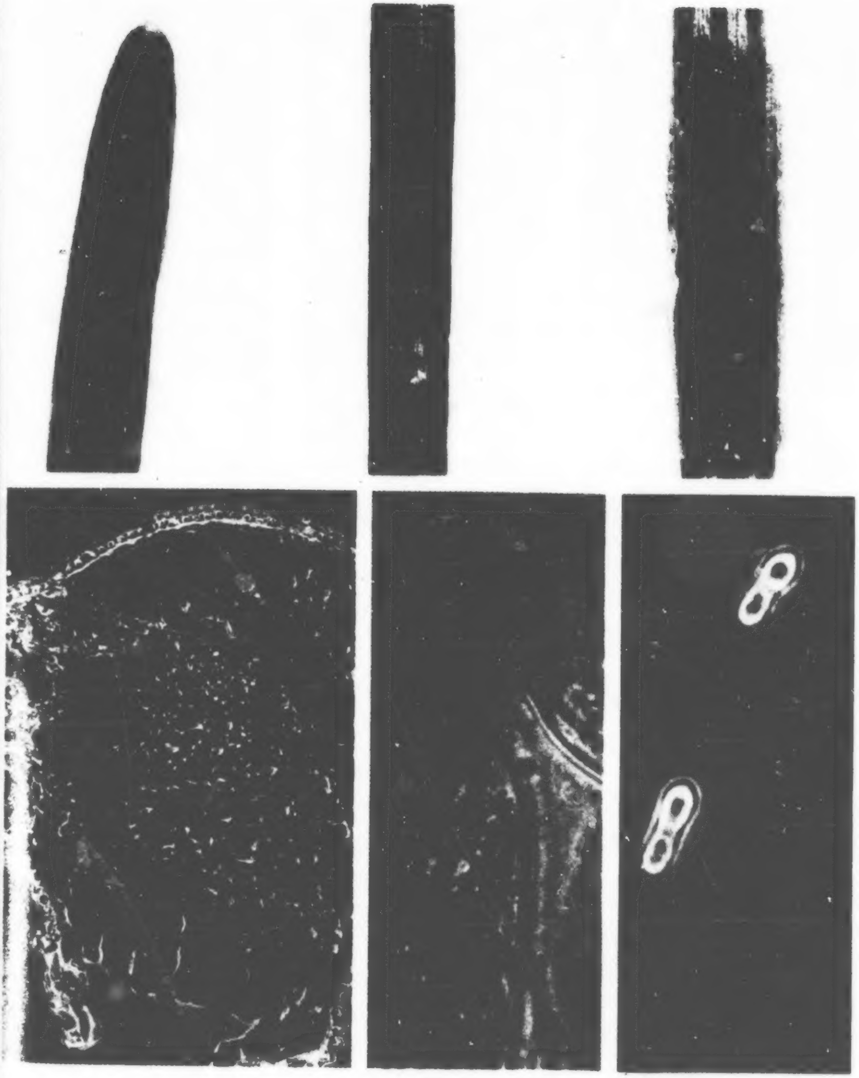


Fig. 54. *Rhabdocline weirii. Rhabdogloeum* state on upper surface of needle (left). Ascomata of subsp. *oblonga* (mid) and of subsp. *obovata* (right). Needle section of subsp. *weirii* showing *Rhabdogloeum* state above, ascoma below. Ascus tips showing iodine positive pore. Conidia of *Rhabdogloeum pseudotsugae*.

Rhizosphaera kalkhoffii Bub. Ber. Deutsch. Bot. Gesell. *32:* 188 (1914).

IN CULTURE: *Hormonema*

Pycnidia black, globose, smooth, lacking an ostiole, emerging from stomata in regular rows, carrying the waxy stomatal plug on top, 45-75 × 30-85 μm, with a stalk of mycelial strands, pycnidial wall one cell thick. Conidiophores absent. Conidiogenous cells monophialidic in the pycnidial wall. Conidia nonseptate, hyaline, elliptic to ovoid, rounded at the ends, 5-10 × 3-5 μm.

HOSTS: *Abies*, *Pinus*, *Pseudotsuga*

DISEASE: Needle blight (Kumi and Lang 1979; Tanaka and Chiba 1971).

NOTES: Waterman (1947) reported the disease in eastern North America, but it is widespread in the west at a moderate level. ***R. oudemansii*** Maubl., with conidia 9-16 × 5-9 μm, has been reported on *Tsuga* needles from Alaska (Sutton 1980).

Rhizosphaera pini (Corda) Maubl. Bull. Soc. Mycol. France *23:* 171 (1907).

Pycnidia black, subglobose, smooth, with a small apical ostiole, emerging from stomata in regular rows, carrying the waxy stomatal plug on top, 50-65 × 55-125

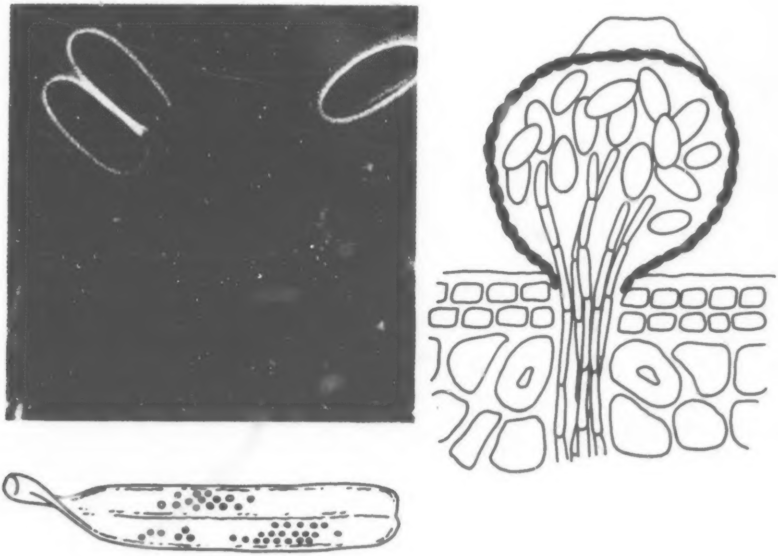


Fig. 55. *Rhizosphaera pini.* Pycnidia on needle. Pycnidium emerging from stomate. Conidia (after Diamandis and Minter).

μm, supported by a stalk-like mycelial strand, pycnidial wall one cell thick. Conidiophores absent. Conidiogenous cells monophialidic in pycnidial wall. Conidia hyaline, nonseptate, elliptic to ovoid, rounded at the ends, 15-32 × 7-12 μm (Fig. 55).

HOSTS: *Picea sitchensis*, *Pinus monticola*, *Abies lasiocarpa*

DISEASE: Needle blight.

NOTES: In culture *R. pini* produces rudimentary pycnidia (Gourbiere and Morelet 1980).

Rhizothyrium abietis Naum. Bull. Soc. Mycol. France *30:* 423 (1915).

TELEOMORPH: *Rhizocalyx abietis* Petrak

Conidiomata superficial, with clypeus of dark brown radiating filaments, supported by a central columella or hyphal mass; inner tissue hyaline, flaring outward parallel to the clypeus, terminating in the conidiophores. Conidiomata 70-200 μm diameter, 20-40 μm thick. Conidiophores 6-10 μm long. Conidiogenous cells phialidic, terminal. Conidia hyaline, elliptic, 3-septate, 16-23 × 5-6 μm (Fig. 56).

Apothecia superficial, stalked, black, smooth, 100-320 μm diameter, 190-250 μm high. Asci clavate, thickened at the apex, pore stained blue in iodine, 8-spored, 65-115 × 10-16 μm. Paraphyses filiform, colored at the tips. Ascospores hyaline, elliptic to clavate, 0-4-septate, guttulate, 9-28 × 4-6 μm.

HOST: *Abies lasiocarpa*

DISEASE: Weakly parasitic on needles, frequently associated with other pathogens such as *Phaeocryptopus nudus* and *Nothophacidium phyllophilum* (q.v.) (Darker 1965).

NOTES: The relationship of the teleomorph of *Rhizothyrium abietis* was proven by Smerlis (1967); it appears to be rare in the west.

Fig. 56. *Rhizothyrium abietis*. Conidioma and conidia.

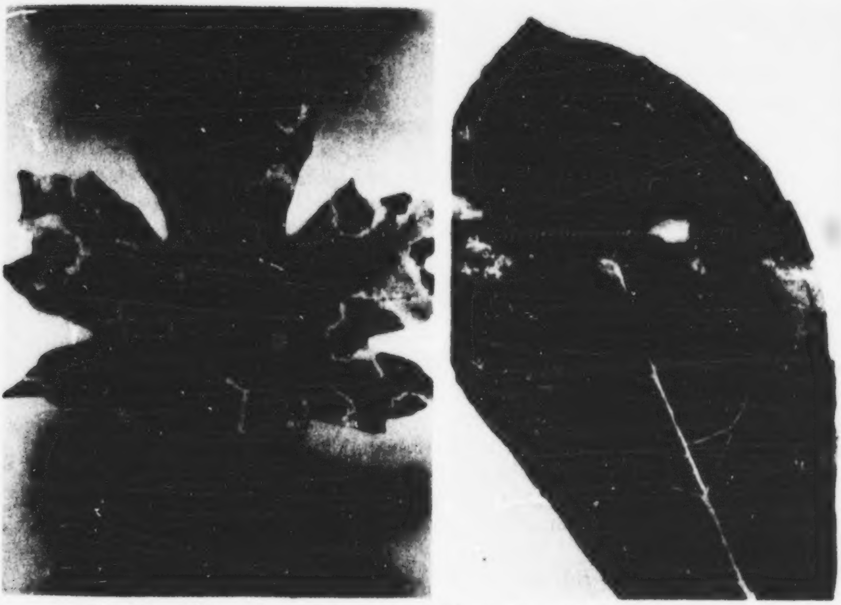


Fig. 57. *Rhytisma punctatum.* Ascomata on broadleaf maple. *R. salicinum*, stromata on willow.

Rhytisma punctatum (Pers.) Fr. Syst. Mycol. *2:* 569 (1823).

ANAMORPH: *Melasmia punctata* Sacc. & Roum.

Stromata black, punctate or speck-like, circular, approximately 1 mm diameter, 20-30 aggregated in infected area of leaf, each containing a single apothecium or hymenial area. Asci clavate, 70-80 × 9-10 μm, 8-spored. Ascospores filiform, slightly broader above, nonseptate, guttulate, hyaline, 30-36 × 1.5-2 μm. Paraphyses filiform (Fig. 57).

Pycnidia forming in stromata singly. Conidiophores cylindric, simple or branched. Conidia allantoid, hyaline, 4-6 × 1 μm. Conidiogenous cells enteroblastic, phialidic.

HOSTS: *Acer macrophyllum, A. spicatum*

DISEASE: Speckled tar spot of maple leaves.

NOTE: Apothecia develop in the stromata of the fallen leaves and the ascospores are released in spring.

Rhytisma salicinum (Pers.) Fr. Syst. Mycol. *2:* 568 (1823).

ANAMORPH: *Melasmia salicina* Lev.

Stromata black, circular, raised in the center approximately 2-5 mm diameter on the upper surfaces of leaves, containing numerous hymenial areas or apothecia which become exposed by fissures in the crust, disc grey. Asci clavate, 8-spored, 120-150 × 10-15 μm. Ascospores filiform, hyaline, 60-90 × 1.5-3 μm, nonseptate, guttulate. Paraphyses filiform.

Pycnidia forming in the stromata, 2-3 in number, 130-160 μm diam. Conidiophores densely crowded on basal stratum, 16-23 × 1-2 μm. Conidia cylindric, hyaline, 5-6 μm long. Conidiogenous cells enteroblastic, phialidic (Sutton 1980).

HOST: *Salix*

DISEASE: Tar spot of willow leaves (Fig. 57).

NOTES: The pycnidial state forms first. The apothecia form in the same stromata after leaves have fallen.

Rhytisma arbuti Phillips was reported on tar spot of *Arbutus menziesii* (madrone) on the west coast (see discussion under *Coccomyces arbutifolius*).

Rosellinia herpotrichioides Hept. & Davidson Phytopathology *27:* 307 (1937).

Subiculum a light gray mycelial mat, forming under leaves and branches. Perithecia embedded in subiculum, black, carbonaceous, wrinkled, papillate, gregarious, globose, 500-900 μm diameter. Asci cylindric, with gelatinous pore at the apex, 8-spored, 185-210 × 11-14 μm. Ascospores uniseriate, dark brown, unicellular, inequilaterally ovate, with longitudinal germ slit, 23-26 × 9-10 μm (Fig. 58).

Botrytis-like conidial state produced in subiculum, conidia hyaline, ovoid, 5-8 × 3-5 μm.

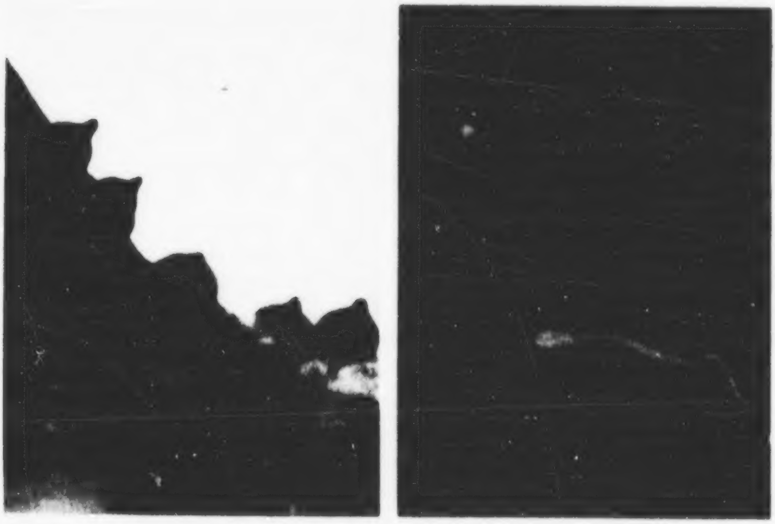


Fig. 58. ***Rosellinia herpotrichioides*. Perithecia. Ascus and ascospores.**

HOST: *Pseudotsuga menziesii*

DISEASE: Causing twig and leaf blight (smothering-disease) of young Douglas-fir seedlings in nurseries.

NOTES: This species on seedlings in British Columbia has smaller spores than the type, and is considered a new species by S.M. Francis (personal communication).

Sarcotrochila alpina (Fckl.) Hoehn. Sitzb. K. Akad. Wiss. Wien *126:* 310 (1917).

SYNONYMS: *Naemacyclus alpinus* Fckl., *Stegia alpina* (Fckl.) Rehm

Apothecia amphigenous, sessile, subepidermal and then erumpent, dehiscing laterally producing a lid of epidermis, irregularly rectangular, 0.4-0.8 mm long; covering layer lacking; hymenium yellowish-brown. Asci clavate, 8-spored, pore bluing in iodine (J+), 45-55 × 10-12 μm. Ascospores fusiform, hyaline and nonseptate at first, but may become light brown and 1-3-septate in age. Paraphyses simple, septate, up to 9 μm wide above, far exceeding length of asci.

HOST: *Larix lyallii*

DISEASE: Needle blight of young trees (Ziller 1969a).

NOTES: The fungus fruited on red-brown attached needles. Occasionally associated with *Lophodermium laricinum*. Rare.

Sarcotrochila macrospora Ziller & Funk Can. J. Bot. *51:* 1960 (1973).

Apothecia amphigenous, sessile, subepidermal and then erumpent producing a circumscissile lid of epidermis, subcircular to polygonal, 200-500 × 300-800 μm; excipulum poorly developed, reddish-brown, 20-30 μm thick; covering layer lacking; hymenium flat, brownish. Asci cylindrical to truncate-clavate, 8-spored, pore staining blue in iodine (J+), 90-145 × 10-15 μm. Ascospores hyaline, clavate, nonseptate, 50-100 × 2-4 μm, sometimes with a knob at lower end. Paraphyses filiform, septate, swollen at the apex, sometimes branched (Fig. 59).

HOST: *Pinus contorta*

DISEASE: Secondary invader of needles attacked by *Davisomycella ampla*.

NOTE: Found on two- to three-year-old needles on trees growing not more than 8 km from the seashore.

Sarcotrochila piniperda (Rehm) Korf Mycologia *54:* 30 (1962).

SYNONYM: *Naevia piniperda* Rehm

Apothecia amphigenous, intraepidermal, erumpent, pushing a flap of epidermis up. Excipulum of parallel rows of dark walled, septate hyphae, free at the tips. Asci clavate, 8-spored, pore blue in iodine (J+), 55-90 × 6-9 μm. Ascospores hyaline, nonseptate, ellipsoid, 9-14 × 3.5-6 μm. Ascospores in overwintered apothecia may become brown, 1-2-septate. Paraphyses filiform, slightly swollen at the apex.

HOSTS: *Picea sitchensis*, *P. glauca*

DISEASE: Secondary to *Lirula macrospora*. Reid and Cain (1962) considered it the cause of snow-blight of spruce but this does not appear to occur in the west (Table 5).

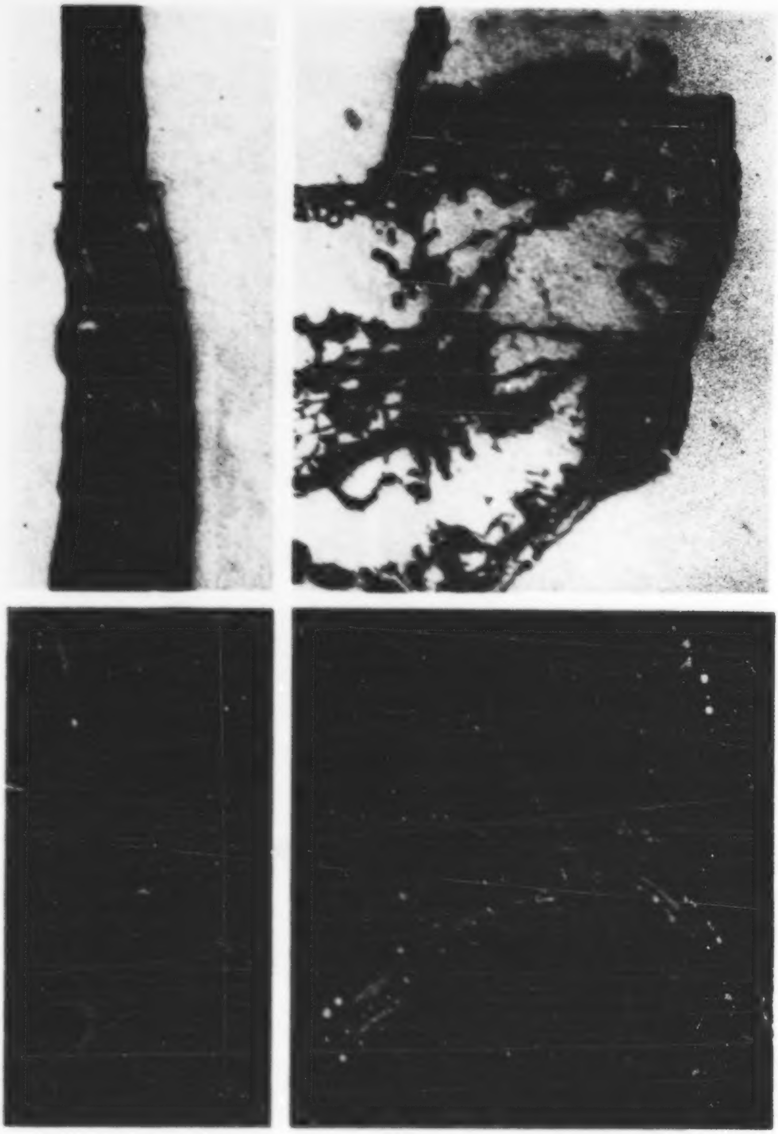


Fig. 59. *Sarcotrochila macrospora*. Ascomata on pine needle. Vertical section, ascoma. Ascus and paraphyses showing J+ ascus pore. Ascospores.

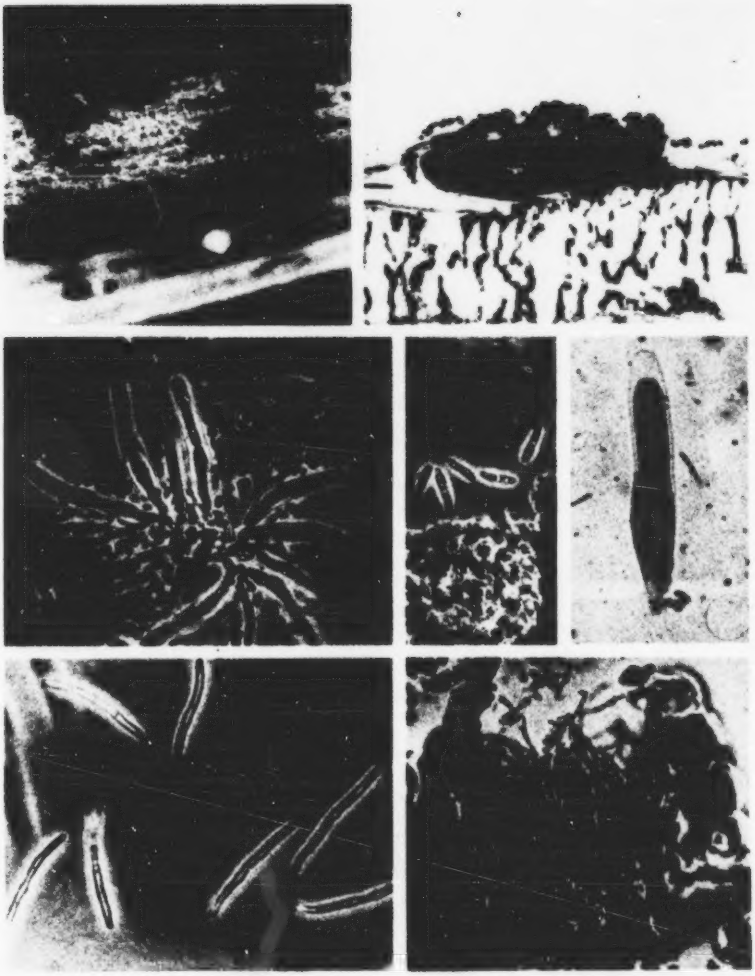


Fig. 60. *Scirrhia pini.* Ascomata in pine needle. Ascoma, vertical section. Ascus and ascospores. *Dothistroma* anamorph, vertical section. Conidium.

Fig. 61. *Scirrhia pini*. Needle blight of pine showing fruiting bodies in red bands.

Scirrhia pini Funk & Parker Can. J. Bot. *44:* 1171 (1966).
ANAMORPH: *Dothistroma pini* Hulbary
SYNONYM: *Dothistroma septospora* (Dorog.) Morelet

Ascostromata black, linear, multiloculate, subepidermal, erumpent, 200-600 × 95-150 μm; tissues pseudoparenchymatous, cells 7-14 μm diameter; locules globose, in longitudinal order, 40-86 μm diameter. Asci cylindric or clavate, bitunicate, apex rounded, 8-spored, 46-52 × 8-10 μm, separated by pseudoparaphysoids. Ascospores hyaline, 1-septate, fusiform to cuneate, 13-16 × 3-4 μm (Figs. 1, 60, 61).

Conidial stromata linear, subepidermal, erumpent, dark brown or black, 125-1500 μm long, 50-450 μm wide, up to 600 μm high. Conidial locules parallel to the longitudinal axis of stroma, without a distinct wall. Conidia hyaline, scoleciform, 1- to 5- but usually 3-septate, blunt at the ends, straight, slightly curved, or bent, 16-64 × 3.5 μm. Conidiophores numerous, approximately the same size as the conidia, hyaline or amber, dense, unbranched, producing conidia at their tips.

HOSTS: *Pinus*

DISEASE: Red band needle blight of pines. Universal and potentially very damaging (Gibson 1974; Parker 1972; Shaw and Leaphart 1960).

NOTES: Three varieties of the anamorph are recognized, based primarily on conidial length. *D. pini* var. ***linearis*** Thyr & Shaw, the longest spore form, is found in western North America (syn. *D. septospora* var. *lineare* (Thyr & Shaw) Sutton).

The life cycle is completed in one-year at the coast but requires two-years in most other parts of the west (Peterson and Graham 1974).

A purplish-red stain is given off by fruit bodies mounted in dilute KOH that fades in a few minutes.

Fruiting bodies form in the red bands and split the epidermis. Spores are released from April to November and may infect needles of all ages (Funk and Parker 1966; Parker and Collis 1966).

Copper fungicides effectively control the disease and should be applied just before and shortly after the new needles emerge.

Sclerophoma pithyophila (Corda) Hoehn. Fragmente z. Mykol. *402:* 1234 (1909).

TELEOMORPH: *Sydowia polyspora* (Bref. & Tav.) E. Muller

CULTURE: *Hormonema dematioides* Lagerb. & Melin

Pycnidia immersed, then erumpent, black, globose to irregular, separate or gregarious, unilocular or imperfectly divided, walls of dark brown parenchyma, rather thick, without ostiole, upper wall disintegrating, 150-300 μm diameter. Inner hyaline cells becoming dolioform and producing a single phialidic aperture. Conidia hyaline, ovate to obovate, with central guttule, 4-8 × 2-3 μm. A bright red pigment is often produced in the locule (Fig. 62).

Pseudothecia immersed, then partially erumpent, black, glabrous, frequently grooved on the top, subglobose, up to 150 μm diameter of dark parenchyma. Asci cylindric, thickest below, bitunicate, 70-100 × 22-26 μm, 16-spored. Ascospores hyaline, oval with 1-6 transverse septa, constricted at the center septum, sometimes muriform with 1-3 longitudinal septa, 10-25 × 3-8 μm.

HOSTS: *Pinus* spp., *Pseudotsuga*, *Abies* spp., *Picea* spp., *Tsuga heterophylla*, *Larix*, *Thuja*

DISEASE: Follows drought, frost damage and other injuries in most conifers, causing canker, dieback and needle blight. The ascigerous stage is very

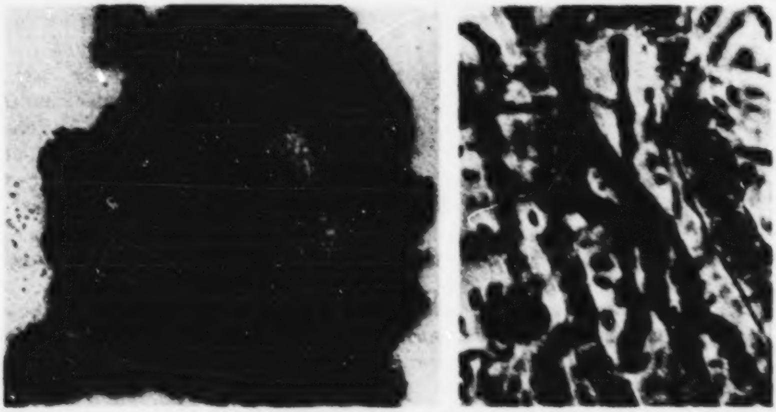


Fig. 62. *Sclerophoma pithyophila*. Pycnidium.

rare, but the pycnidial stage is produced abundantly in bark or needles.

NOTES: In culture, this fungus produces a dark *Hormonema* state characterized by an appressed colony with metallic sheen (Hermanides-Nijhof 1977) and conidia produced basipetally from a single locus in an undifferentiated cell.

Seiridium cardinale (Wagener) Sutton & Gibson C.M.I. Descriptions of Pathogenic Fungi and Bacteria 326 (1972).

SYNONYM: *Coryneum cardinale* Wagener

Acervuli black, peridermal to subperidermal, of pale brown irregular pseudoparenchyma, more hyaline in the conidiogenous region, 200-300 μm diameter. Conidiophores cylindric, branched, septate, hyaline, up to 25 μm long, 2 μm wide, frequently intermingled with hyphae up to 50 μm long that may be paraphyses. Conidiogenous cells holoblastic, annellidic, determinate, hyaline, 8-17 × 2 μm. Conidia formed at the tips, 5-euseptate, broadly fusiform, constricted slightly at the equidistant septa, smooth, 21-30 × 8-9 μm. Median cells equally dark brown; apical cell hyaline, conic with a short appendage 1 μm long; basal cell hyaline, truncate with marginal frill, with or without an endogenous appendage 1 μm long. (Fig. 63).

HOST: *Thuja plicata*

DISEASE: The cause of a serious shoot and leaf blight of native *Thuja* and ornamental Cupressaceae.

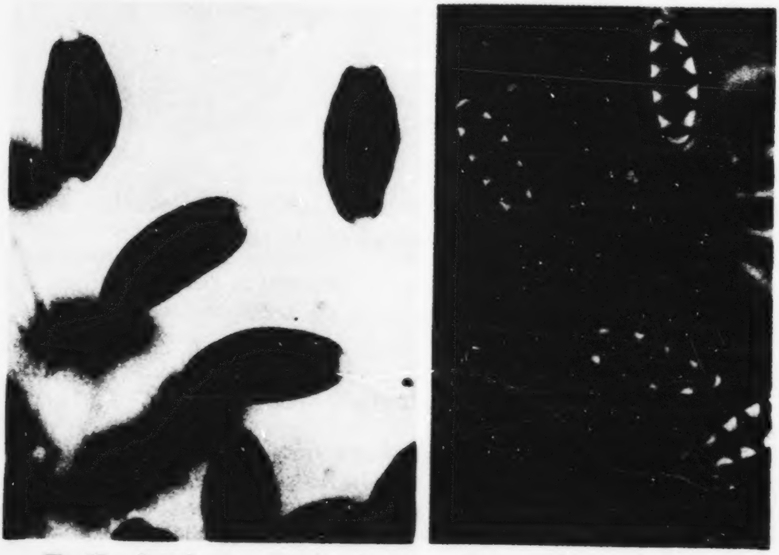


Fig. 63. ***Seiridium cardinale.*** **Conidia.** ***Seimatosporium berckmansii.*** **Conidia.**

NOTES: Swart (1973) considers this fungus to be a variant of *Monochaetia unicornis* (Cooke & Ell.) Sacc., having the teleomorph *Lepteutypa cupressi* (Nattrass, Booth & Sutton) Swart, but this has not been confirmed in Canada. Sutton (1975) transferred *M. unicornis* to *Seiridium unicorne* (Cooke & Ell.) Sutton because the genus *Monochaetia* is characterized by 4-euseptate conidia (Sutton 1969).

Seimatosporium (Coryneum) berckmansii (Milb.) Sutton attacks ornamental Cupressaceae and has 5-septate conidia 29-32 × 9-10 μm with collapsed periclinal walls (Fig. 63).

Septoria aceris (Lib.) Berk. & Br. Ann. N. Hist. No. 432 ? (1850).

Pycnidia dark, subglobose, clustered in leaf spot, approx. 300 μm diameter, ostiole single, central, circular. Conidiophores absent. Conidiogenous cells holoblastic, sympodial. Conidia hyaline, 3-septate, filiform, smooth, 55-65 × 1.5-2 μm (Fig. 64).

HOST: *Acer glabrum* var. *douglasii*

DISEASE: Leaf spot of maple. Spots are 3-5 mm diameter, irregular, yellowish.

NOTE: For Septorias on poplar, see *Mycosphaerella*, the teleomorph.

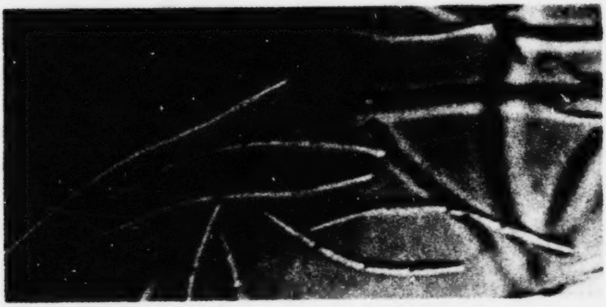


Fig. 64. *Septoria aceris.* Conidia.

Septoria alni Sacc. Michelia *1:* 177 (1879).

Pycnidia epiphyllous, thin-walled, black, approx. 200 μm diameter, ostiole single, central. Conidiophores absent. Conidiogenous cells holoblastic, sympodial.

Conidia hyaline, continuous, guttulate, filiform, curved, 30-40 × 1.5-2.5 μm.

HOST: *Alnus sinuata*

DISEASE: Leaf spot of alder. Spots are small (5 mm) irregular, brownish.

NOTES: Another similar species on alder leaves is ***Septoria alnifolia*** Ell. & Ev. with larger conidia (40-65 × 2 μm). *Cylindrosporium alni* Dearn. is a *nomen nudum*. It is probable that both of these names are referrable to *S. alni*.

In a recent revision Constantinescu (T.B.M.S. *83:* 383-398) shows conidia multiseptate in both species and 10-15 μm longer than given here.

Sirococcus strobilinus Preuss   Linnaea *26:*716 (1854).
SYNONYM: *Ascochyta piniperda* Lindau

Pycnidia erumpent on shoots and needles, grayish green to black, subconical to spherical, ostiolate, 0.3-1.0 mm diameter; peridium of dark prosenchyma, lined with hyaline interwoven hyphae, 30-50 µm thick, cavity simple. Conidiophores simple or branched, septate, each cell with a single phialide at the tip or just below the septum, 10-45 µm long; phialides tapering, sharply pointed, 6-12 × 2 µm. Conidia hyaline, medianly 1-septate, tips acute, slightly constricted at the septum, acerose to fusiform, 13-15 × 2-2.5 µm (Fig. 65).

HOSTS: *Tsuga heterophylla*, *Pinus* spp., *Picea* spp., *Pseudotsuga menziesii*

DISEASE: Causes shoot and leaf blight of various conifers, but is most serious on western hemlock regeneration, in pine nursery stock and spruce germinants in British Columbia.

NOTES: This fungus often fruits on cones and spores may become seedborne. Killing of spruce germinants has been shown by the seedborne spores from natural sources (Sutherland *et al.* 1981).

Stegopezizella balsameae (Davis) Syd.   Ann. Mycol. *22:*392 (1924).
SYNONYM: *Sarcotrochila balsameae* (Davis) Korf
ANAMORPH: *Gloeosporium balsameae* Davis
SYNONYM: *Rhabdogloeopsis balsameae* (Davis) Petrak

Apothecia circular, erumpent through the epidermis and pushing up a circular flap of host tissue, less than 1 mm diameter; excipulum of parallel, brown, gelatinized hyphae, hypothecium of small polygonal cells. Asci clavate, long-stalked, 8-spored, pore bluing in iodine especially after pretreatment with dilute KOH, 85-125 × 15-20 µm. Ascospores at first hyaline and nonseptate, (10-25 µm long), broadly ellipsoid to ovoid, becoming brown and 3-septate, 24-30 × 7-10 µm. Paraphyses filiform, simple or branched, tips swollen (Fig. 66).

Conidiomata acervular, subepidermal, basal layer of brown polygonal cells. Conidiophores densely covering base, hyaline, septate, branched, with acropleurogenous conidia. Conidiogenous cells holoblastic, sympodial, indeterminate, cylindric, with 1-3 sympodial proliferations on the apices. Conidia hyaline, nonseptate, fusiform, straight or curved, 20-35 × 4-6 µm.

HOSTS: *Abies amabilis*, *A. lasiocarpa*, *A. grandis*, *A. concolor*, *A. balsamea*

DISEASE: Unresolved differences of opinion exist on pathogenicity: Reid and Cain (1962b) and Bonar (1962) considered it the cause of needle death but Ziller (1968) and Darker (1932) considered it to be secondary to the hypodermataceous needle pathogens, *Isthmiella* and *Lirula* (Table 5).

Stigmina thujina (Dearn.) Sutton   C.M.I. Mycol. Paper 138: 175 (1975).

Acervuli or sporodochia occurring on a pseudoparenchymatous, dark brown stroma that is immersed in the leaf but ruptures the cuticle and measures 150-230 × 70-120 µm. Conidiophores short, giving rise to cylindrical, light brown conidiogenous cells. Conidiogenous cells annellidic with up to five percurrent proliferations, 16-20 × 3-4 µm. Conidia brown, curved-cylindric to obclavate,

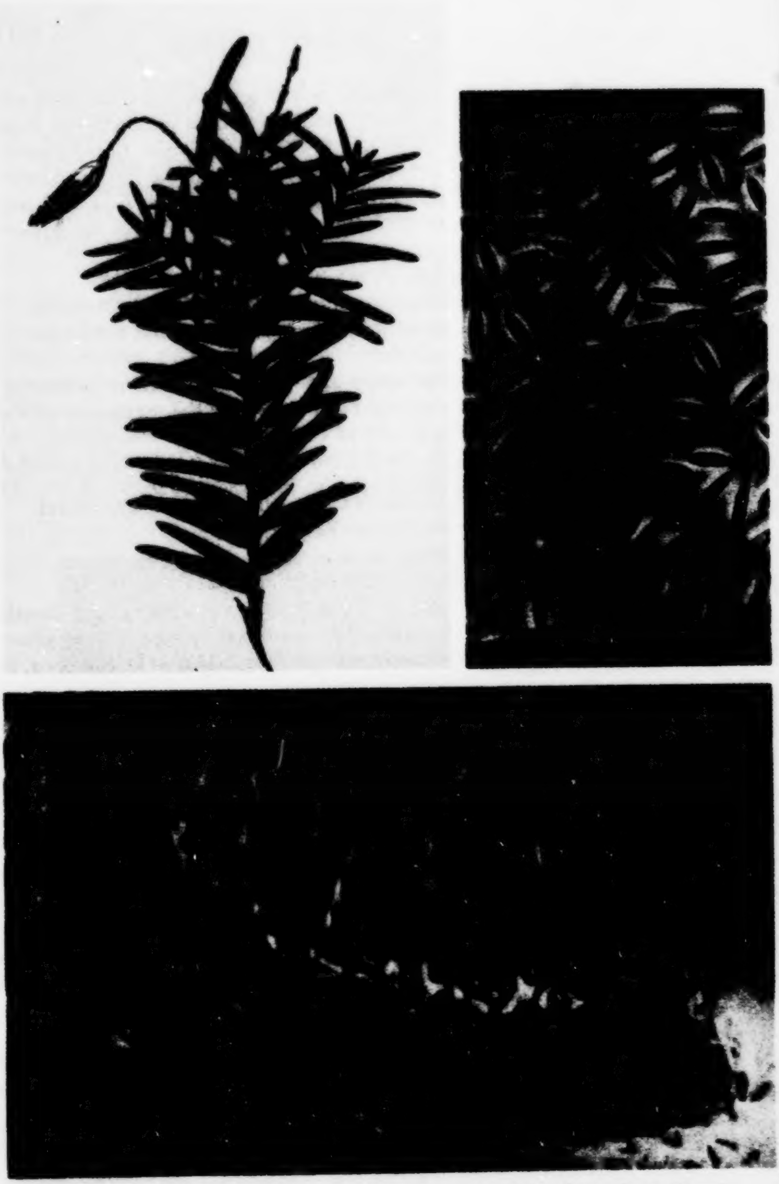


Fig. 65. *Sirococcus strobilinus.* Leaf and shoot blight of hemlock. Pycnidial wall with conidiophores. Conidia.

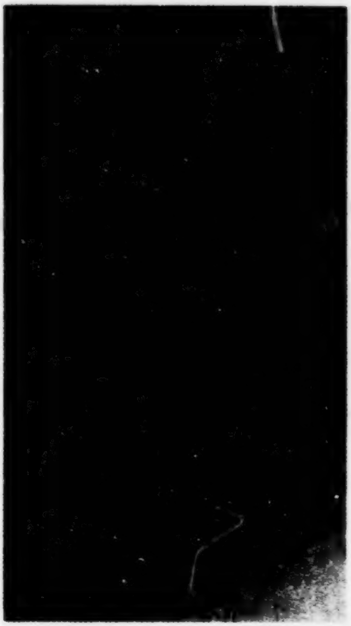


Fig. 66. *Stegopezizella balsameae.* Asci and ascospores (note ascus pore bluing in iodine after treatment with dil. KOH).

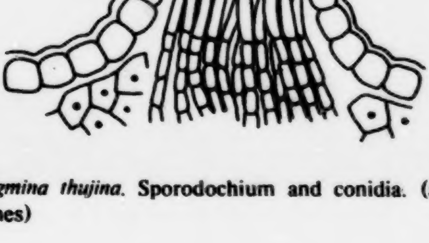


Fig. 67. *Stigmina thujina.* Sporodochium and conidia. (after Morgan-Jones)

truncate with basal frill, guttulate, smooth-walled, 5-10-septate, 40-52 × 6-8 μm, 3-5 μm wide at the base (Fig. 67).

HOST: *Thuja plicata*

DISEASE: Parasitic on western red cedar leaves.

NOTE: *Stigmina verrucosa* (Morgan-Jones) Sutton causes yellow spots on spruce needles; the obclavate conidia are verrucose, 5-7-septate and measure 40-45 × 5-8 μm. Morgan-Jones (1971) gives full descriptions of the Stigminas under the name *Sciniatosporium*.

Stomiopeltis pinastri (Fckl.) Arx Beitr. Krypt. Schweiz *11:* 545 (1962).

Ascomata shield-like (thyriothecia), flattened on leaf surface, circular, brown, 85-175 μm diameter, with central pore, composed of radially oriented hyphae. Asci cylindric to ellipsoid, 15-18 × 4-7 μm, bitunicate. Ascospores hyaline, 1-septate in the middle, bitunicate, fusoid-ellipsoid, 6-8 × 1.5-2 μm.

HOST: *Pinus monticola*

DISEASE: "Black mildew" or "fly speck" of living needles.

NOTE: An undescribed *Stomiopeltis* is common on living needles of Douglas-fir causing "fly speck."

Taphrina Fr. Syst. Orbis Veg. *1:* 317 (1825).

Asci formed in palisade layer on living plant surface, usually seated on small basal cells. No fruiting body is produced, and there are no paraphyses. Ascospores hyaline, globose to ellipsoid, often budding in the ascus to give large numbers of similar secondary spores; growth in culture is yeast-like, and budding also occurs on the host to form infectious secondary spores.

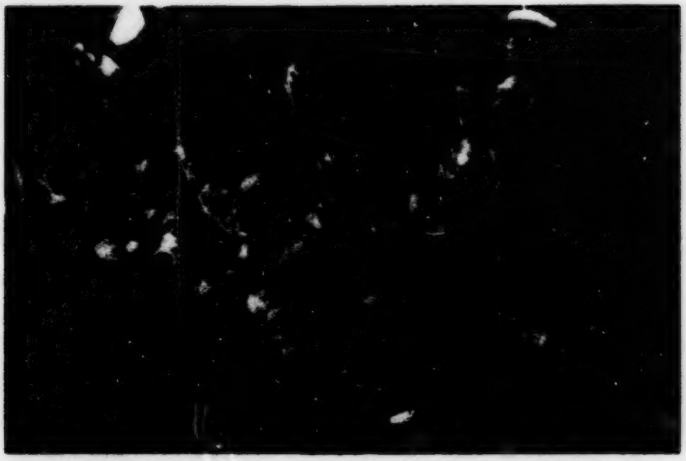
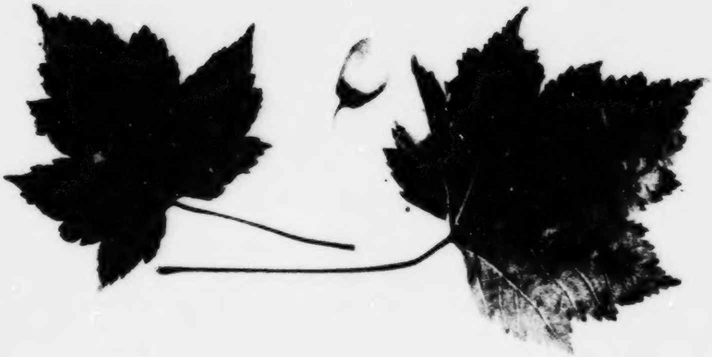


Fig. 68. ***Taphrina americana*. Broom and leaf spot in birch.**



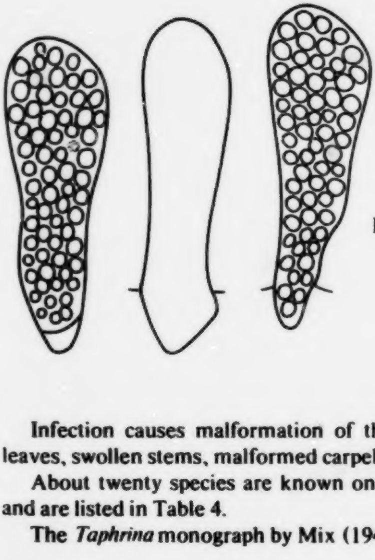


Fig. 69. *Taphrina darkeri*. Leaf spot of maple. *Taphrina populina*. Asci (after Mix).

Infection causes malformation of the host, such as blister-like swellings on leaves, swollen stems, malformed carpels, witches' brooms (Figs. 68, 69).

About twenty species are known on leaves of western trees (all angiosperms) and are listed in Table 4.

The *Taphrina* monograph by Mix (1949) is a standard reference.

Thyriopsis halepensis (Cooke) Theiss. & Syd. Ann. Mycol. *13:* 369 (1915).

Thyriothecia black, amphigenous, subcuticular, elongate to roundish, covering layer of brown, isodiametric cells, opening by splits, 90-600 × 60-180 μm, 30-80 μm thick. Asci ovoid, bitunicate, 8-spored, 25-45 × 20-28 μm. Ascospores ellipsoid, medianly 1-septate, hyaline to brown at maturity, thick-walled, 11-16 × 4-8 μm.

Table 4. *Taphrina* species

Species	Symptoms	Asci	Ascospores	Hosts
T. americana Mix	leaf spot and witches' brooms	17-40 × 8-18 µm	3.5-5.5 × 4-6 µm	*Betula papyrifera* (Fig. 68)
T. bacteriosperma Johans.	yellowing of leaves	33-80 × 14-20 µm	3-6 × 1-2 µm	*Betula glandulosa*
T. boycei Mix	leaf spots	30-60 × 20-36 µm	4-5 × 4 µm	*Betula occidentalis* *B. papyrifera*
T. caerulescens (Desm.) Tul.	swollen leaf spots			*Quercus garryana*
T. confusa (Atk.) Gies.	deforming leaves	23-53 × 7-13 µm	4-7 × 3-6 µm	*Prunus virginiana*
T. darkeri Mix	leaf spots	16-33 × 8-13 µm	4 × 3.5 µm	*Acer glabrum* (Fig. 69)
T. flava Farlow	leaf spots (small)	30-63 × 15-33 µm	5-6 × 5 µm	*Betula papyrifera*
T. flectans Mix	leaf curl and witches' broom	20-43 × 7-12 µm	4-6 × 4-5 µm	*Prunus emarginata*
T. japonica Kusano	leaf curl with thickening	33-92 × 13-33 µm	4-5.5 × 4-5 µm	*Alnus rubra*
T. nana Johans.	leaf yellowing	13-30 × 8-15 µm	3.5-6 × 3.5-5 µm	*Betula glandulosa*
T. populina Fries	golden yellow leaf spots	30-122 × 13-30 µm	4-6.5 × 4-5 µm	*Populus* hybrids *P. nigra* *P. tremuloides* (Fig. 69)
T. populi-salicis Mix	golden yellow leaf spots	50-106 × 13-30 µm	1.5-5 × 0.5-4.5 µm	*Populus trichocarpa* *Salix* sp.

Conidia produced in same thyriothecium before the asci, hyaline, ovoid to cylindrical, nonseptate, 4-5 × 2 μm. Conidiophores clavate to cylindrical, 15-30 × 2-3 μm, sometimes persisting and appearing as paraphyses in between the asci.

DISEASE: Associated with chlorotic spots on living needles.

HOSTS: *Pinus*

NOTE: Ouellette (1966) described the conidial form and suggested that they may act as spermatia.

Tiarosporella pseudotsugae Whitney, Reid & Pirozynski Can. J. Bot. *53:* 3057 (1975).

Pycnidia hypophyllous, subepidermal, scattered, black, ovoid or elongate, 600-1000 × 300 μm, wall pseudoparenchymatous, ostiole lateral. Conidiophores of cells lining inner wall, conical, holoblastic, approximately 10 μm high. Conidia hyaline, nonseptate, cylindric, slightly swollen at the apex, with flattened scar at the base, 42-65 × 4-5 μm, at maturity with a mucilaginous, apical appendage of irregular shape (cf. Fig. 69a).

HOST: *Pseudotsuga menziesii*

NOTES: On *Abies* spp. there is ***Tiarosporella abietis*** Whitney, Reid & Pirozynski with conidia 29-45 × 5-8 μm; on *Picea* spp. there is ***Tiarosporella parca*** (Berk. & Br.) Whitney, Reid & Pirozynski with conidia 23-40 × 4-6 μm. These species are both associated with *Darkera* spp. (q.v.) but relationships have not been proven (Fig. 69a).

Truncatella truncata (Lev.) Steyaert Bull. Jard. Bot. Brux. *25:* 191 (1955).

Acervuli black, erumpent, pseudoparenchymatous, up to 350 μm diameter. Conidiophores simple or branched at the base, cylindric, 24 × 2 μm. Conidiogenous cells holoblastic, annellidic, 11-21 × 2 μm. Conidia holoblastic, acrogenous, 3-euseptate, broadly fusiform or slightly bent, constricted at the septa, 18 × 8 μm; median cells thick-walled, brown; end cells thin-walled, hyaline, the apical cell with a single irregularly branched appendage up to 13 μm long (Fig. 70).

HOST: *Tsuga heterophylla*

DISEASE: Infects needles but may be secondary.

NOTES: The segregates of the genus *Pestalotia* display constancy in conidial septation: *Truncatella* is 3-septate, *Pestalotiopsis* and *Monochaetia* are 4-septate, *Pestalotia* and *Seiridium* are 5-septate (Sutton 1969).

Uncinula bicornis (Fr.) Lev. Ann. Sci. Nat. Bot. III, *15:* 153 (1851).

ANAMORPH: *Oidium aceris* Rab.

Perithecia superficial on leaf, subglobose, nonostiolate, black, up to 170 μm diameter, on the upper half bearing many short (approximately 150 μm) spreading appendages forked at the tip, the branches recurved to form a double hook. Asci 4-12 in number, pear-shaped, 70-95 × 45-55 μm, 8-spored. Ascospores hyaline, nonseptate, ellipsoid, 22-26 × 13-15 μm (Fig. 71).

Conidia ellipsoid, 25-35 × 15-20 μm.

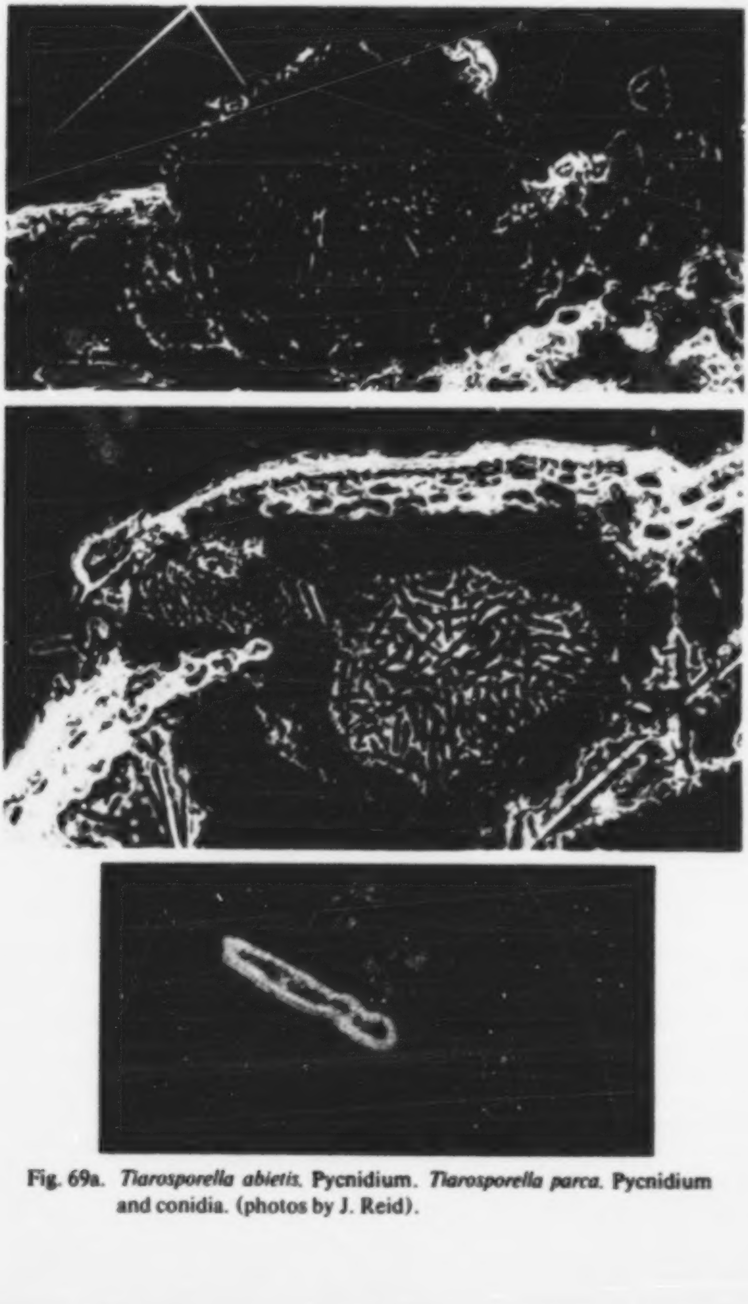


Fig. 69a. *Tiarosporella abietis.* Pycnidium. *Tiarosporella parca.* Pycnidium and conidia. (photos by J. Reid).

Fig. 70. *Truncatella truncata.* Conidia.

Fig. 71. *Uncinula bicornis.* Perithecia from powdery mildew of maple.

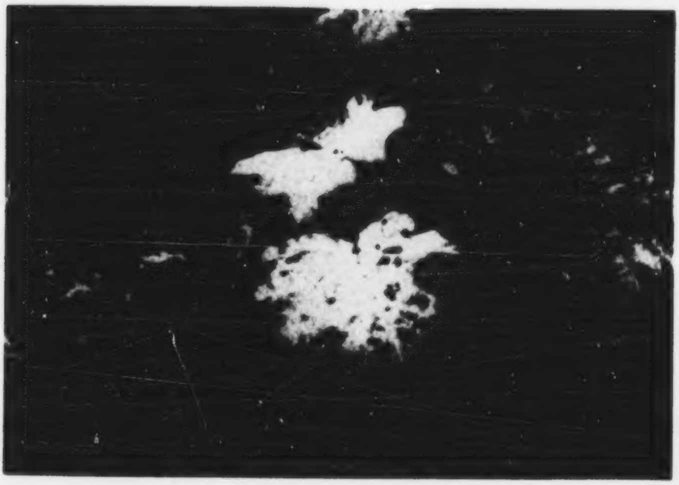


Fig. 72. Powdery mildew of broadleaf maple.

HOST: *Acer*

DISEASE: Powdery mildew of maple leaves (Fig. 72).

Uncinula salicis (DC.) Winter Rab. Krypt. Fl. *1*(2): 40 (1887).

SYNONYM: *Uncinula adunca* Lev.

ANAMORPH: *Oidium*

Perithecia superficial on leaf, subglobose, nonostiolate, dark brown, bearing many simple, hyaline appendages with recoiled tips around the equatorial zone. Asci pear-shaped, 8-12 in number, 66-90 × 38-52 μm, 4-5-spored. Ascospores broadly ellipsoid, hyaline, 25-30 × 15-19 μm.

Conidia ellipsoid, 25-35 × 11-20 μm.

HOSTS: *Populus*, *Salix*

DISEASE: Powdery mildew of leaves of poplar and willow.

Vanterpoolia tsugae Funk Can. J. Bot. *60:* 973 (1982).

Sporodochia semiglobose, sessile, reddish-orange, translucent, hard when dry, soft when moistened, up to 0.5 mm diameter. Conidiophores simple septate, 75-105 × 1.5-2.0 μm, arising in dense cluster from a scant pseudoparenchymatous base. Conidia triradiate or cylindric, blastopores, appendaged, produced in acropetal chains, hyaline, septate, 30 × 15 μm (Fig. 73).

HOST: *Tsuga heterophylla*

DISEASE: Found on necrotic, newly flushed needles. Pathogenicity not proved; apparently rare (Funk 1982).

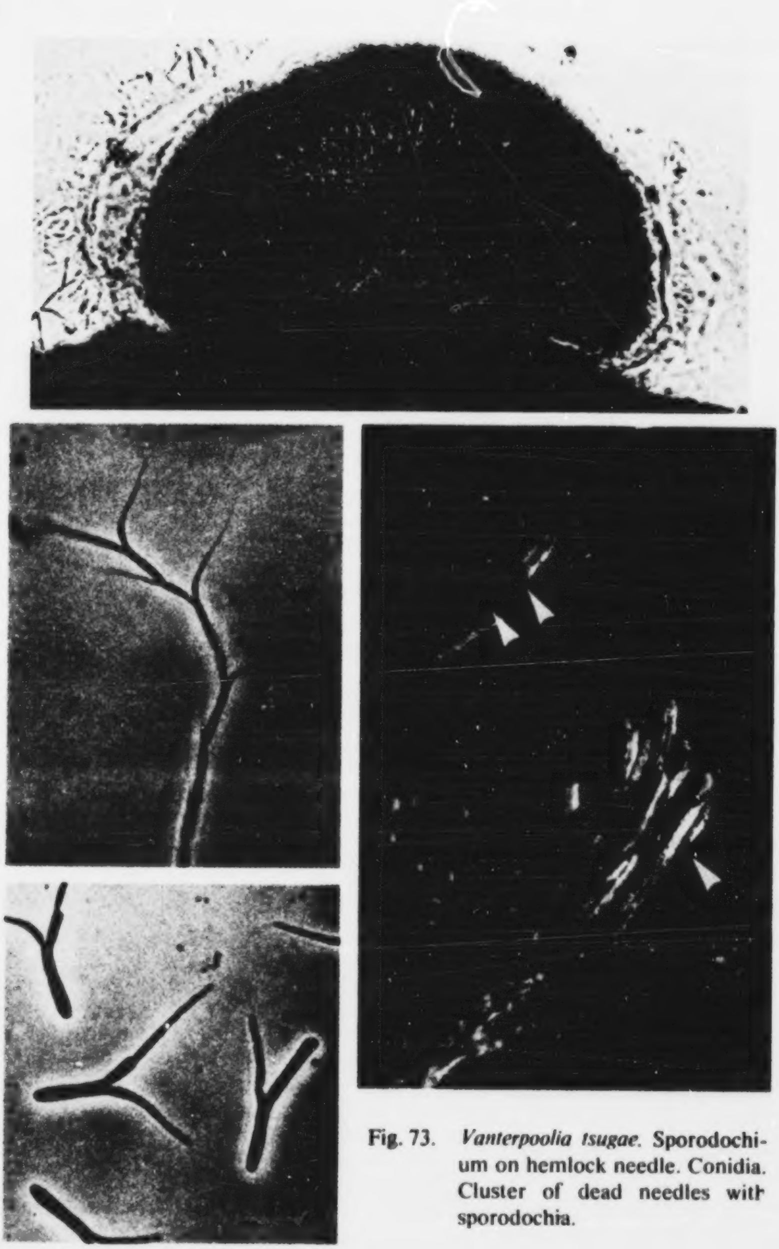


Fig. 73. *Vanterpoolia tsugae*. Sporodochium on hemlock needle. Conidia. Cluster of dead needles with sporodochia.

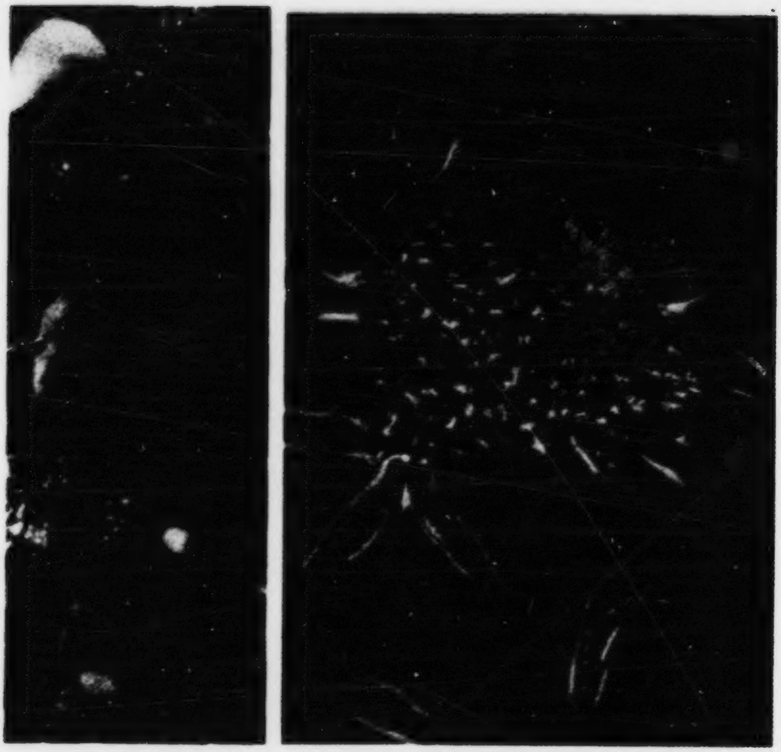


Fig. 74. *Venturia macularis*. Leaf and shoot blight of aspen. Conidia.

Venturia macularis (Fr.) E. Müller & Arx   Ber. Schw. Bot. Gesell. *60:* 366 (1950).

SYNONYM: *Venturia tremulae* Aderh.[*]

ANAMORPHS: *Pollaccia americana* Ondrej
Pollaccia radiosa (Lib.) Bald. & Cif.

Ascomata immersed, globose to conical, erumpent, glabrous or setose, wall of brown polygonal cells, 80-140 μm diameter, setae 30-50 μm long, apical pore 25-50 μm wide. Asci oblong to saccate, bitunicate, 2-4-8-spored, 42-63 × 10-12 μm. Ascospores greenish to brown, elliptical to clavate, straight or inequilateral, 1-septate in the middle or below, slightly constricted, sometimes finely roughened, sometimes with a gelatinous coating, 8-14 × 4.5-6 μm.

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[*] Barr (1968) synonymized *Venturia tremulae* Aderh. with *V. macularis* but Morelet (1983) considered *V. tremulae* distinct with three varieties.

Acervuli irregular, olive-green. Conidiophores brown, nonseptate, 8-12 × 4-6 µm. Conidia brown, ellipsoid to cylindrical, straight or bent, 0-2-septate, 12-22 × 6-7 µm.

HOST: *Populus tremuloides*

DISEASE: Causes leaf and shoot blight of poplars (Fig. 74).

NOTES: A closely related species attacks black and balsam poplars, viz., ***V. populina*** (Vuill.) Fabric. (ANAMORPH: *P. elegans* Serv.) which has larger ascospores (20-23 × 11-13 µm) and straight conidia (25-36 × 8-14 µm) (Fig. 74a) (Dance 1961).

Considerable variation has been noted in some *Venturia* species and it is possible that races exist. Pollaccias are also difficult to distinguish and the work of Ondrej (1972) has facilitated identification.

Venturia saliciperda Nüesch Phytopath. Z. *39:* 350 (1960).

ANAMORPH: *Pollaccia saliciperda* (Allesch. & Tub.) Arx

SYNONYM: *Fusicladium saliciperdum* (Allesch. & Tub.) Lind

Ascomata immersed, globose to conical, papillate, setose, 80-120 µm diameter, wall of two layers of brown cells. Asci oblong to saccate, bitunicate, 35-55 × 8-12 µm. Ascospores narrowly ellipsoid, 1-septate slightly above the middle, slightly greenish, 11-14 × 3-5 µm.

Conidial state developing on shoots and leaves, in brown irregular spots; conidiophores annellate, cylindric to conic, 8-15 × 5-8 µm. Conidia ellipsoid to cylindric, 1-2-septate, greenish-brown to olivaceous, 16-23 × 6-9 µm, base truncate.

HOSTS: *Salix* spp.

DISEASE: Cause of willow blight, often associated with *Glomerella cingulata* in this disease.

Fig. 74a. ***Venturia populina.*** **Conidia.**

Virgella robusta (Tub.) Darker Can. J. Bot. *45:* 1419 (1967).
SYNONYM: *Hypoderma robustum* Tub.

Hysterothecia hypophyllous, dark brown, innate, extending along full length of needle, up to 0.5 mm wide, nervisequious, opening by a longitudinal fissure, primordium of slit conspicuous, covering layer of dark pseudoparenchyma 30-40 μm thick, basal layer of hyaline plectenchyma. Asci saccate-clavate, 8-spored, 138-192 × 28-35 μm. Ascospores rod-shaped, hyaline, nonseptate, 27-36 × 4-8 μm, with mucilaginous sheath up to 11 μm thick that swells after discharge. Paraphyses filiform, simple, straight, hyaline, 120-150 × 0.5 μm (Fig. 4).

Pycnidia epiphyllous, in two rows on each wing of the reddish-brown needle, intraepidermal, maturing before the asci, continuous, concolorous at first, up to 280 μm wide. Conidia hyaline, rod-shaped, 3-3.5 × 0.5-0.7 μm.

HOSTS: *Abies amabilis*, [*A. grandis*, *A. concolor*, *A. magnifica*]

DISEASE: Needle blight. One of the most important foliage diseases of balsam fir.

NOTES: *V. robusta* has a two-year life cycle and so is found on needles two-years old or older. It is often followed by *Lophodermium consociatum*.

Table 5. **Secondary fungi on conifer needles**

Secondary Fungus	Primary Fungus Followed	Host Tree
Hemiphacidium longisporum	*Lophodermella concolor*	*Pinus contorta*
Hemiphacidium planum	*Bifusella linearis*	*Pinus monticola*
	Davisomycella medusa	*P. ponderosa*
	Elytroderma deformans	*P. ponderosa*
	Lophodermella concolor	*P. contorta*
Hendersonia pinicola	*Lophodermella concolor*	*Pinus contorta*
	L. sulcigena	
Leptosphaeria faullii	*Isthmiella abietis*	*Abies lasiocarpa*
	I. quadrispora	
Lophomerum autumnale	*Isthmiella abietis*	*Abies amabilis*
	I. quadrispora	*Abies lasiocarpa*
Lophomerum darkeri	*Lirula macrospora*	*Picea glauca*
Nothophacidium phyllophilum	*Lirula abietis-concoloris*	*Abies lasiocarpa*
Sarcotrochila macrospora	*Davisomycella ampla*	*Pinus contorta*
Sarcotrochila piniperda	*Lirula macrospora*	*Picea sitchensis*
	P. glauca	
Stegopezizella balsameae	*Isthmiella quadrispora*	*Abies* spp.
	I. abietis	
	Lirula abietis-concoloris	

Appendix

Uredinales (Rusts)

(ref. *The Tree Rusts of Western Canada* by W.G. Ziller)

The foliar rusts of western trees and their alternate hosts have been described by Ziller (1974). They are listed here under host genus of A) conifers, B) broadleaved trees.

Fruit bodies are usually tongue-like or horn-like projections from non-necrotic leaves, orange, yellow or white in color. Spores are usually large, with thick, warted or sculptured walls, and brightly colored. The pycnial state, however, is a colorless, sunken fruit body with small, thin-walled spermatia (conidia) that could be confused with a coelomycete (Figs. 75-84).

In some cases the same rust is reported on both coniferous and broadleaved hosts. This is so because of host alternation in some rusts. The primary host is that on which the pycnial and aecial states are produced, and the alternate host is that on which the uredinial, telial and basidial states are produced. This is a unique characteristic among the parasitic fungi in that two unrelated hosts are required to complete the life cycle. Both conifers and broadleaved trees may be either primary or alternate hosts.

1) Rusts on conifer needles

Abies Needle cast or blight or symptomless. Aecial states of the following rusts:
Hyalopsora aspidiotus P. Magn.
Melampsora abieti-capraearum Tub.
Melampsora medusae Thuem.
Melampsora occidentalis Jacks.
Melampsorella caryophyllacearum Schroet.
Milesina laeviuscula (Diet.) Hirat. f.
Pucciniastrum epilobii Otth
Pucciniastrum goeppertianum (Kuehn) Kleb.
Uredinopsis hashiokai Hirat. f.
Uredinopsis longimucronata Faull
Uredinopsis phegopteridis Arth.
Uredinopsis pteridis Diet. & Holw.
Uredinopsis struthiopteridis Stoerm.:Diet.

Chamaecyparis Orange leaf spot. Uredinial and telial states of:
Gymnosporangium nootkatense Arth.

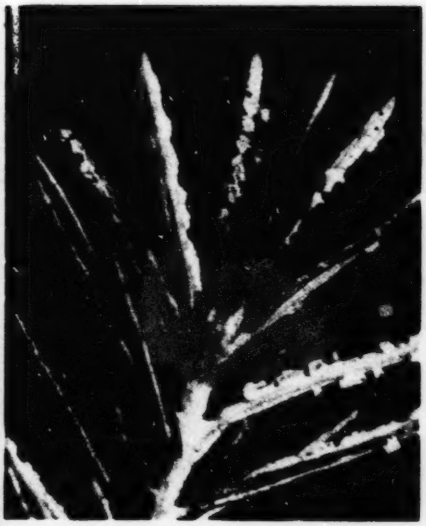


Fig. 75. *Chrysomyxa ledicola.* Aecia on spruce.

Fig. 76. *Coleosporium asterum.* Aecia on pine.

Fig. 77. *Melampsorella caryophyllacearum.* Aecia on alpine fir.

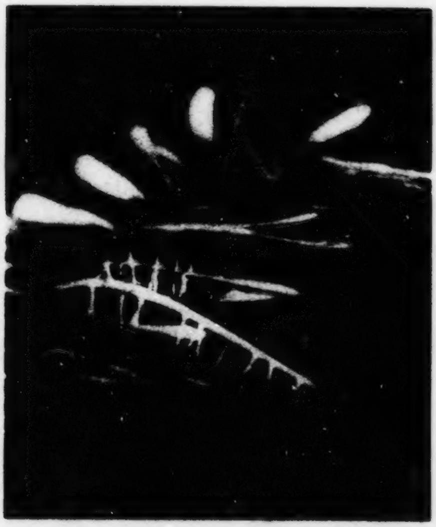


Fig. 78. *Milesina laeviuscula.* Aecia on grand fir.

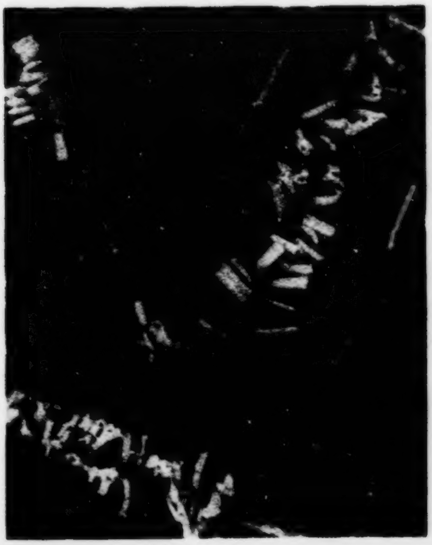


Fig. 79. *Pucciniastrum epilobii.* Aecia on alpine fir.

Fig. 80. *Gymnosporangium bethelii*
Roestelia on hawthorn.

Fig. 81. *Gymnosporangium fuscum.* Aecia on pear. Trellis-like aecia.

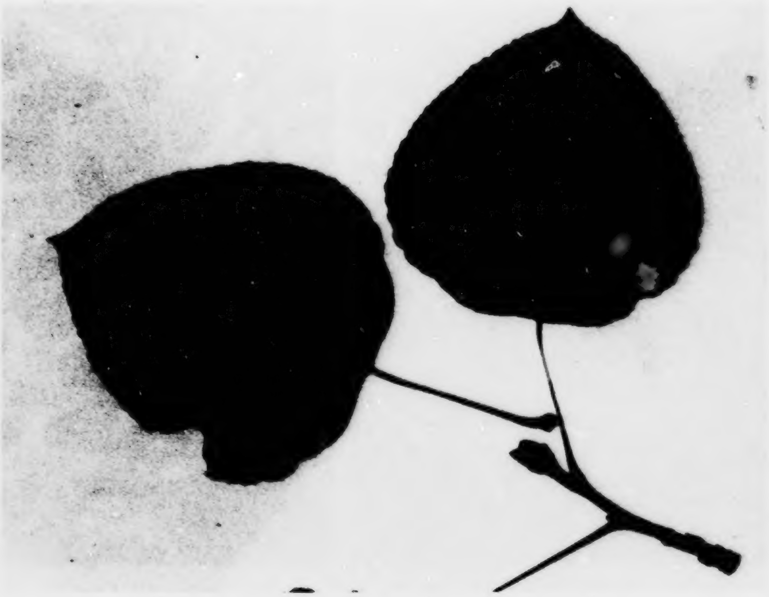


Fig. 82. *Melampsora medusae*. Uredinia on aspen.

Juniperus Leaf blight. Uredinial and telial states of:
Gymnosporangium cornutum Arth.
Gymnosporangium gaeumannii Zogg
Gymnosporangium haraeanum Syd.
Gymnosporangium inconspicuum Kern

Larix Premature defoliation of larch. Aecial states of:
Melampsora medusae Thuem.
Melampsora occidentalis Jacks.
Melampsora paradoxa Diet. & Holw.

Picea Premature defoliation. Aecial states of:
Chrysomyxa arctostaphyli Diet.
Chrysomyxa empetri Schroet. ex Cumm.
Chrysomyxa ledi de Bary var. *ledi*
Chrysomyxa ledicola Lagerh.
Chrysomyxa woroninii Tranz.
Melampsora medusae Thuem.
Melampsora occidentalis Jacks.
Pucciniastrum americanum (Farl.) Arth.

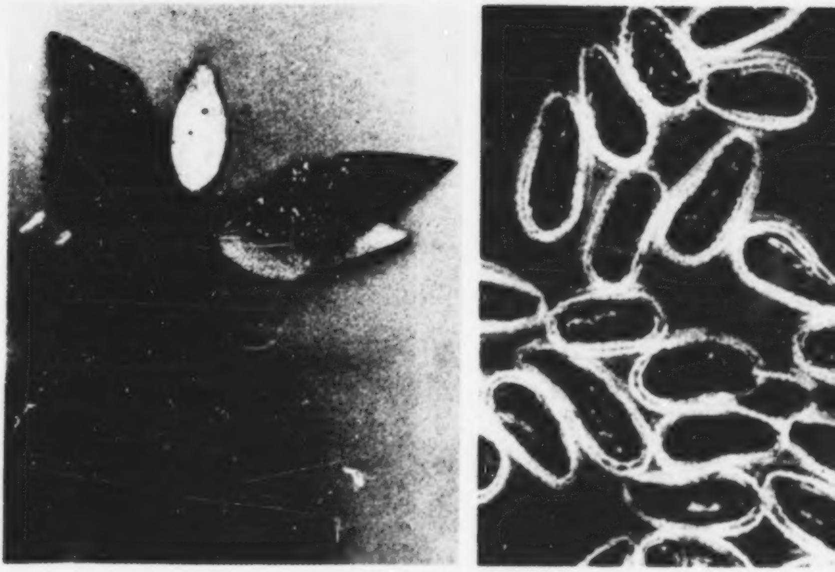


Fig. 83. *Melampsora occidentalis.* Uredinia on black cottonwood. Urediniospores.

Fig. 84. *Pucciniastrum sparsum.* Uredinia on Arbutus.

Pucciniastrum arcticum Tranz.
Pucciniastrum sparsum (Wint.) E. Fischer

Telial state of:
Chrysomyxa weirii Jacks.

Pinus Needle blight and defoliation. Aecial states of:
Coleosporium asterum (Diet.) Syd.
Melampsora medusae Thuem.
Melampsora occidentalis Jacks.

Pseudotsuga Needle blight. Aecial states of:
Melampsora medusae Thuem.
Melampsora occidentalis Jacks.

Tsuga Needle discoloration and necrosis. Aecial states of:
Melampsora epitea Thuem. f. sp. *tsugae* Ziller
Melampsora medusae Thuem.
Pucciniastrum vaccinii (Wint.) Joerst.

2) Rusts on broadleaf foliage

Amelanchier Yellow leaf spot. Aecial states (roestelia) of:
Gymnosporangium clavariiforme (Pers.) DC.
Gymnosporangium nelsonii Arth.
Gymnosporangium nidus-avis Thaxt.

Arbutus Brown spot in purple areas of leaves. Uredinial and telial states of:
Pucciniastrum sparsum (Wint.) E. Fischer

Betula Mottled yellowing of leaves. Uredinial and telial states of:
Melampsoridium betulinum Kleb.

Crataegus Yellow leaf spot. Aecial states of:
Gymnosporangium bethelii Kern
Gymnosporangium clavariiforme (Pers.) DC.

Populus Yellow leaf spot and premature defoliation of black cottonwood and aspen. Uredinial and telial states of:
Melampsora medusae Thuem. (on aspen)
Melampsora occidentalis Jacks. (on cottonwood)

Pyrus Orange-red leaf spot of pear. Aecial state of:
Gymnosporangium fuscum Hedw. f. in DC.

Rhamnus Yellow leaf spot. Aecial state of:
Puccinia coronata Corda

Salix Yellow leaf spot. Uredinial and telial states of:
Melampsora epitea Thuem. complex of races.

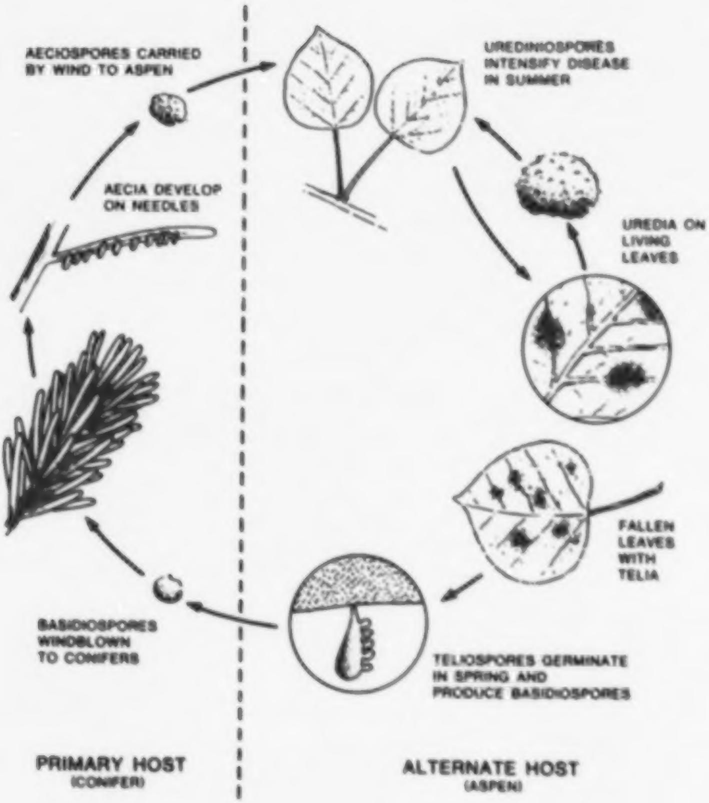

AECIOSPORES CARRIED BY WIND TO ASPEN
UREDINIOSPORES INTENSIFY DISEASE IN SUMMER
AECIA DEVELOP ON NEEDLES
UREDIA ON LIVING LEAVES
FALLEN LEAVES WITH TELIA
BASIDIOSPORES WINDBLOWN TO CONIFERS
TELIOSPORES GERMINATE IN SPRING AND PRODUCE BASIDIOSPORES
PRIMARY HOST (CONIFER)
ALTERNATE HOST (ASPEN)

Fig. 85. Life cycle diagram of *Melampsora medusae*, a rust fungus that alternates from conifer to aspen.

Glossary

acervulus: fruiting structure of certain Deuteromycotina, consisting of a shallow aggregation of hyphae and bearing conidiophores on the upper surface.
acicular: slender and pointed, needle-shaped.
acrogenous: at the tip, apical.
acropleurogenous: at the tip and sides.
acuminate: a narrowing to a point.
acute: pointed, less than a right angle.
allantoid: sausage-shaped, slightly curved with rounded ends.
amphigenous: growing all around or on both sides.
ampulliform: flask-shaped.
amyloid: stained blue black by Melzer's Iodine; symbol J+. (cf. dextrinoid).
anamorph: the imperfect state of a fungus; asexual, mitotic diasporic expression of a fungus.
annellophore: a conidiogenous cell with a series of ring-like scars left by succeeding blastic conidia (annellospores).
anthracnose: leaf necrosis caused by acervular fungi .
apical: at the tip.
apothecium: the cup- or saucer-shaped fruit body of the Discomycetes, containing asci.
appendage: a process or outgrowth.
arthrospore: spore produced from breaking up a hypha into separate cells.
ascigerous: having asci.
ascocarp: the ascus bearing fruit body of an Ascomycete.
ascomycetes: the Ascomycotina, or Sac fungi; typified by the ascus, within which are produced ascospores usually eight in number, but in some species more or less than eight.
ascospore: a spore produced within an ascus by free cell formation.
ascostroma: a stroma containing asci, as in the Loculoascomycetes.
ascus: a sac-like cell of an Ascomycete within which ascospores are produced.
aseptate: without crosswalls.
asexual: vegetative, without sex organs, imperfect, not involving nuclear fusion.
basidiomycetes: the Basidiomycotina, a large subdivision of the fungi characterized by presence of the basidium bearing basidiospores; includes the mushrooms, polypores, etc.
basipetal: development in direction of the base, making the apical part the oldest.
bifusiform: elongate with a narrow central isthmus.
biseriate: having two walls, as in the asci of Loculoascomycetes.
blastospore: a spore produced by blowing-out of the cell wall and enlarging before being delimited by a septum. (cf. holoblastic, enteroblastic).
blight: leaf damage that is sudden and serious (see also *needle blight*).

botryose: grouped like grapes.

budding: development of a spore from a small outgrowth.

caespitose: in groups or clusters, frequently arising from a common stroma.

catenulate: in chains, chain-like.

cirrhus: a tendril-like mass of forced-out spores.

clavate: club-like, narrowed at the base.

cleistothecium: an ascocarp having no special opening.

clypeus: a shield-like growth over a perithecium.

coelomycete: a division of the Deuteromycotina (Fungi Imperfecti) consisting of Sphaeropsidales and Melanconiales, q.v.

concolorous: of one color

conidiogenous cell: a cell from which a conidium is directly produced.

conidioma: general term for an asexual fruit body, i.e., the anamorphic phase.

conidiophore: a hypha bearing conidiogenous cells from which conidia are produced.

conidium: an asexual spore.

continuous: having no septa.

cuneate: wedge-like.

dehiscent: opening when mature by pores or by breaking up.

deliquescent: becoming liquid after maturing.

dematiaceous: more or less darkly pigmented.

deuteromycetes: Fungi Imperfecti; characterized by the absence of a sexual state.

dextrinoid: stained reddish-brown by Melzer's Iodine.

dictyospore: a spore having longitudinal and transverse septa; muriform.

dieback: death of the outermost twigs or extremities of the branches or leaders. Dieback can be caused by stress complexes or by invasion and girdling of stems by canker fungi.

discomycetes: the cup-fungi, with asci produced in an apothecium.

distoseptate: having each cell surrounded by a wall distinct from the common outer wall.

ecto-: outside.

endo-: inside.

enteroblastic: where only the inner wall, or no wall, contributes to the formation of conidia.

epiphyllous: on the upper surface of the leaf.

epithecium: the surface of the disc in certain Discomycetes.

erumpent: bursting through the bark.

euseptate: septa in which the diaphragm merges with the outside wall.

evanescent: soon disappearing, ephemeral.

excipulum: tissues of the apothecium; ectal-, forms outermost layers, including the margin, and medullary-, the zone enclosed by the ectal excipulum and the hypothecium.

falcate: curved like the blade of a sickle.

filiform: thread-like.

floccose: cottony.

fruit body: a general term for spore-bearing organs.

gall: a swelling or outgrowth produced by a plant as the result of fungus attack.

glabrous: smooth, not hairy.

globose: spherical or almost so.

guttulate: having one or more oil drops inside.

holoblastic: where both outer and inner walls contribute to the formation of a conidium.

host: a living organism harboring a parasite.

hyaline: transparent; colorless.

hymenium: the spore bearing layer of a fruit body.

hyphae: the vegetative, microscopic filaments of a mycelium (or spawn), forming the thallus (body) of a fungus.

hyphomycetes: the division of the Deuteromycotina in which conidia are borne on conidiophores not organized into a fruit body.

hyphopodia: a short branch on epiphytic mycelium of Meliolales.

hypophyllous: on the under surface of the leaf.

hypothecium: the hyphal layer under the hymenium of an apothecium.

immersed: embedded in the bark and covered by it.

imperfect state: the asexual spore state, the anamorph.

innate: embedded in or immersed.

inoperculate: without an apical lid, hence opening through a pore or a split at the tip of the ascus.

intercalary: between apex and base.

interthecial: between asci.

ionomidotic: releasing purple brown dye when immersed in dilute KOH. J+: iodine positive, giving a blue color with iodine (cf. J-).

locule: a cavity in a stroma.

loculoascomycetes: a class of the Ascomycotina characterized by bitunicate asci in an ascostroma.

lunate: like a new moon, crescentic.

macroconidium: the larger, diagnostic conidium of a fungus which also has microconidia.

mazaedium: a loose, powdery mass of ascospores free from asci.

microconidium: see macroconidium, sometimes functioning as a male sex cell.

microfungi: fungi having small fruit bodies, requiring magnification for observation.

micron: one-thousandth of a millimetre; approximately one 25,000th of an inch; symbol μm.

moniliform: having swellings at regular intervals, like a string of beads (=monilioid).

mucronate: the end is pointed.

muriform: see dictyospore.

myc-, mycet-, myco-: prefix meaning fungus.

mycelium: a mass of hyphae, the vegetative thallus of a fungus.

mycology: the study of the fungi.

mycoparasite: the parasitism of one fungus by another.

needle blight: fungal attack on foliage of any age and therefore active anytime there is coincidence of high relative humidity and spores (cf. needle cast). Blighted foliage is also cast after spore release.

needle cast: loss of leaves by conifers caused by fungal attack (see *Rhabdocline*, *Lophodermium*, etc.). Only young needles of the current year are attacked.

nervisequious: living or occurring on veins of leaves.

operculate: opening by an apical lid.

ostiole: a pore through which spores are freed from a perithecium or pycnidium.

ovate: like a hen's egg.

papilla: a small rounded process.

paraphysis: upward growing hyphal element interspersed with the asci in the hymenium.

parasite: an organism living on and obtaining its nutrient from another living organism, frequently causing disease in the host.

perfect state: see teleomorph.

periderm: the outermost, corky layer of bark of a tree.

perithecium: the subglobose or flask-shaped ascocarp of the Pyrenomycetes.

phialide: an enteroblastic conidiogenous cell that produces conidia through a special opening where neither wall contributes toward formation of the conidium, often with a collarette surrounding the opening.

phloem: inner bark which functions in transport of elaborated foods from the leaves.

phragmospore: a spore having two or more transverse septa.

plectenchyma: tissue formed by hyphae becoming twisted and fixed together.

primary needles: in pine where single needles are produced in young stage.

pruinose: having a frost-like covering.

pseudoparenchyma: tissue composed of more or less isodiametric cells.

pycnidium: the globose or flask-shaped fruit body of the Sphaeropsidales containing conidia (pycnidiospores).

pyrenomycetes: the fungi producing unitunicate asci in perithecia.

sclerotium: a sterile mass of hyphae, usually rounded and firm.

secondary needles: in pine the normal needles (cf. primary needles).

septum: a cross wall forming a division, as in a spore or hypha.

sessile: having no stem.

seta: a stiff hair or bristle.

sinuate: waved, curved.

snow blight: a blight disease of conifer foliage and twigs that develops under snow (see *Phacidium*).

snow mould: a smothering disease of conifer foliage that develops under snow (see *Herpotrichia*).

sooty mould: dark, superficial growth of a fungus.

species: in taxonomy, a division of a genus, usually based on morphological characters.

spermatium: a male sex cell, usually a microconidium in the Ascomycetes.

spore: the reproductive propagule in the fungi.

sporodochium: a conidial fruit body in which the spore mass is supported by a pulvinate body covered with short conidiophores.

spot: leaf disease characterized by numerous isolated circular or angular lesions.

state: a phase of the fungus life cycle; Ascomycetes generally have two states: 1) Perfect state — the sexual or ascigerous state, also known as the *teleomorph.* 2) Imperfect state — the asexual or conidial state, also known as the *anamorph.* Sometimes a second asexual state is produced in culture.

sterile: 1) not producing spores, 2) free from living organisms.

stipitate: with a stalk.

stroma: a mass of fungus tissue on which perithecia or apothecia are produced, or in the Loculoascomycetes, in which ascigerous locules are formed.

subiculum: a net-like, or crust-like growth of mycelium under fruit bodies.

subulate: tapering to a point; awl-shaped.

sympodula: a conidiogenous cell characterized by continued growth of a succession of apices each of which originates below and to one side of the previous apex.

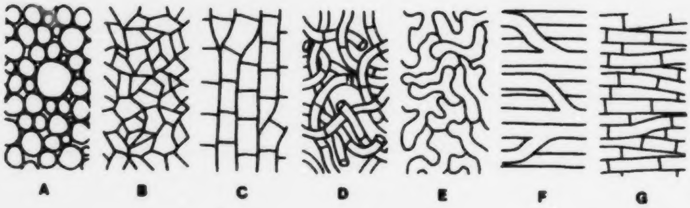
syndrome: a complex of symptoms constituting the picture of a disease.

synnema: a group of erect, fused conidiophores bearing conidia at the apex.

synonym: another name for a fungus, especially a later or illegitimate name.

teleomorph: the perfect or sexual state of a fungus, i.e., the form involved in producing meiotic spores.

textura: tissue of the Ascomycetes.



Short-celled tissue.
A) cells round: *textura globulosa.*
B) cells polyhedral: *textura angularis.*
C) cells rectangular: *textura prismatica.*
Long-celled tissue.
D) hyphae loose, not parallel: *textura intricata.*
E) hyphae united, not parallel: *textura epidermoidea.*
F) hyphae thick-walled, parallel: *textura oblita.*
G) hyphae thin-walled, parallel: *textura porrecta.*

tomentose: having a covering of soft, matted hairs.

uncinate: hooked.

unitunicate: of asci, having only one wall.

valsoid: groups of perithecia with convergent beaks.
verrucose: warty.
verticillate: whorled.
viscid: sticky.

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Host Index

(refs. **Native Trees of Canada** by R.C. Hosie; Hunt and Ziller 1978)

ABIES AMABILIS (Dougl.) Forbes — Amabilis fir

Epipolaeum abietis
Herpotrichia juniperi
Limacinia alaskensis
Lirula abietis-concoloris
Lirula punctata
Lophodermium consociatum
Lophodermium uncinatum
Lophomerum autumnale
Maurodothina farriae
Phacidium abietis
Phaeocryptopus nudus
Rhizosphaera kalkhoffii
Stegopezizella balsameae
Virgella robusta

ABIES GRANDIS (Dougl.) Lindl. — Grand fir

Atichia glomerulosa
Botryosphaeria abietina
Epipolaeum abietis
Hormonema merioides
Limacinia alaskensis
Lirula abietis-concoloris
Lirula punctata
Lophodermium decorum
Lophodermium lacerum
Lophodermium piceae
Maurodothina farriae
Phacidium abietis
Phaeocryptopus nudus
Phyllosticta sp.
Stegopezizella balsameae

ABIES LASIOCARPA (Hook.) Nutt. — Alpine fir

Camarosporium strobilinum
Darkera abietis
Delphinella abietis
Delphinella balsameae
Epipolaeum abietis
Herpotrichia juniperi
Isthmiella abietis
Isthmiella quadrispora
Leptosphaeria faulii
Limacinia alaskensis
Lirula abietis-concoloris
Lirula punctata
Lophodermium decorum
Lophodermium piceae
Lophodermium uncinatum
Lophomerum autumnale
Nothophacidium phyllophilum
Phacidium abietis
Phaeocryptopus nudus
Rhizosphaera pini
Rhizothyrium abietis
Stegopezizella balsameae
Tiarosporella abietis

ACER CIRCINATUM Pursh — Vine maple

Cristulariella depraedans

ACER GLABRUM Torr. var. douglasii (Hook.) Dipp. — Douglas maple
Cristulariella depraedans
Septoria aceris
Taphrina darkeri

ACER MACROPHYLLUM Pursh — Broadleaf maple
Cercosporella aceris
Cristulariella depraedans
Rhytisma punctatum
Uncinula bicornis

ALNUS RUBRA Bong. — Red alder
Cercosporella alni
Cylindrosporium alni
Gnomonia setacea
Phyllactinia guttata
Taphrina japonica

AMELANCHIER ALNIFOLIA (Nutt.) Nutt. — Saskatoon berry
Apiosporina collinsii
Entomosporium mespili
Phyllactinia guttata

ARBUTUS MENZIESII Pursh — Arbutus, Madrone
Capnodium walteri
Coccomyces arbutifolius
Coccomyces dentatus
Didymosporium arbuticola
Mycosphaerella arbuticola
Rhytisma arbuti

BETULA — Birch
Atopospora betulina
Gnomonia campylostyla
Phyllactinia guttata
Taphrina americana
Taphrina bacteriosperma
Taphrina boycei
Taphrina flava
Taphrina nana

CHAMAECYPARIS NOOTKATENSIS (D. Don) Spach — Yellow cedar
Chloroscypha seaveri
Cyanodiscus occidentalis
Kabatina thujae
Pestalotiopsis funerea

CORNUS NUTTALLII Aud. — Western flowering dogwood
Gloeosporium "corni"
Phyllactinia guttata
Phyllosticta cornicola

CRATAEGUS — Hawthorn
Entomosporium mespili

JUNIPERUS — Juniper
Cercospora sequoiae
Chloroscypha sabinae
Herpotrichia juniperi
Kabatina juniperi
Lophodermium juniperi
Pithya cupressina

LARIX — Larch
Apostrasseria lunata
Hypodermella laricis

Lophodermium laricinum
Meria laricis
Mycosphaerella laricina
Sarcotrochila alpina

PICEA ENGELMANNII Parry — Engelmann spruce

Dichomera gemmicola
Herpotrichia coulteri
Herpotrichia juniperi
Isthmiella crepidiformis
Lirula brevispora
Lirula macrospora
Sirococcus strobilinus
Stigmina verrucosa

PICEA GLAUCA (Moench) Voss — White spruce

Camarosporium strobilinum
Dichomera gemmicola
Epipolaeum tsugae
Isthmiella crepidiformis
Lirula brevispora
Lirula macrospora
Lophodermium piceae
Lophomerum darkeri
Lophophacidium hyperboreum
Sarcotrochila piniperda
Sirococcus strobilinus
Stigmina verrucosa

PICEA MARIANA (Mill.) B.S.P. — Black spruce

Isthmiella crepidiformis
Lirula macrospora
Stigmina verrucosa

PICEA SITCHENSIS (Bong.) Carr. — Sitka spruce

Appendiculella pinicola
Dichomera gemmicola
Herpotrichia juniperi
Lirula macrospora
Lophodermium piceae
Phaeocryptopus nudus
Rhizosphaera pini
Sarcotrochila piniperda
Sirococcus strobilinus

PINUS ALBICAULIS Engelm. — Whitebark pine

Bifusella linearis
Bifusella saccata
Gremmeniella abietina
Hemiphacidium planum
Herpotrichia coulteri
Lophodermella arcuata
Lophodermium nitens

PINUS BANKSIANA Lamb. — Jack pine

Davisomycella ampla
Lophodermella concolor
Lophodermella montivaga
Lophodermium molitoris
Lophodermium pinastri
Mycosphaerella dearnessii
Thyriopsis halepensis

PINUS CONTORTA Dougl. — Lodgepole pine

Davisomycella ampla
Davisomycella medusa
Davisomycella montana
Dothistroma pini
Elytroderma deformans
Gremmeniella abietina
Hemiphacidium longisporum
Hendersonia pinicola
Herpotrichia coulteri
Herpotrichia juniperi
Leptomelanconium cinereum
Lophodermella cerina

Lophodermella concolor
Lophodermella montivaga
Lophodermium pinastri
Lophodermium seditiosum
Mycosphaerella dearnessii
Naemacyclus minor
Naemacyclus niveus
Phaeoseptoria contortae
Sarcotrochila macrospora
Scirrhia pini
Sclerophoma pithyophila
Sirococcus strobilinus

PINUS MONTICOLA Dougl. — Western white pine

Bifusella linearis
Cenangium acuum
Dothistroma pini
Hemiphacidium planum
Leptomelanconium allescheri
Linodochium hyalinum
Lophodermella arcuata
Lophodermium nitens
Lophodermium pinastri
Meloderma desmazierii
Rhizosphaera pini
Scirrhia pini
Stomiopeltis pinastri

PINUS PONDEROSA Laws. — Ponderosa pine

Davisomycella medusa
Davisomycella ponderosae
Diplodia pinea
Dothistroma pini
Elytroderma deformans
Gremmeniella abietina
Leptomelanconium cinereum
Lophodermella cerina
Lophodermella morbida
Lophodermium pinastri
Scirrhia pini
Sirococcus strobilinus

POPULUS BALSAMIFERA L. — Balsam poplar

Ciborinia whetzelii
Linospora tetraspora
Marssonina balsamiferae
Venturia populina

POPULUS TREMULOIDES Michx. — Trembling aspen

Ciborinia pseudobifrons
Ciborinia seaveri
Ciborinia whetzelii
Marssonina brunnea
Marssonia populi
Taphrina populina
Uncinula adunca
Venturia macularis

POPULUS TRICHOCARPA Torr. & Gray — Black cottonwood

Linospora tetraspora
Marssonina populi
Mycosphaerella populicola
Mycosphaerella populorum
Taphrina populi-salicis
Uncinula adunca
Venturia populina

PSEUDOTSUGA MENZIESII (Mirb.) Franco — Douglas-fir

Atichia glomerulosa
Botrytis cinerea
Dichomera gemmicola
Epipolaeum pseudotsugae
Hormonema merioides
Limacinia alaskensis
Meria laricis
Phacidium abietis

Phacidium pini-cembrae
Phaeocryptopus gaeumannii
Phomopsis lokoyae
Rhabdocline pseudotsugae
Rhabdocline weirii
Rhabdogloeum hypophyllum
Rhabdogloeum pseudotsugae
Rhizosphaera kalkhoffii
Rosellinia herpotrichioides
Sclerophoma pithyophila
Sirococcus strobilinus
Stomiopeltis sp.
Tiarosporella pseudotsugae

QUERCUS GARRYANA Dougl. — Garry oak
Taphrina caerulescens

QUERCUS MACROCARPA Michx. — Bur oak
Gnomonia quercina

SALIX — Willow
Ciborinia foliicola
Ciborinia wisconsinensis
Marssonina kriegeriana
Rhytisma salicinum
Taphrina populi-salicis
Uncinula salicis
Venturia saliciperda

TAXUS BREVIFOLIA Nutt. — Western yew
Asteridiella pitya
Dothiora taxicola
Phacidium dearnessii
Phyllostictina hysterella

THUJA PLICATA Donn — Western red cedar
Chloroscypha seaveri
Didymascella thujina
Limacinia alaskensis
Phacidium sherwoodiae
Phomopsis lokoyae
Pithya cupressina
Seiridium cardinale
Stigmina thujina

TSUGA HETEROPHYLLA (Raf.) Sarg. — Western hemlock
Colletotrichum acutatum
Colletotrichum gloeosporioides
Epipolaeum tsugae
Fabrella tsugae
Herpotrichia juniperi
Phomopsis lokoyae
Rhizosphaera oudemansii
Sclerophoma pithyophila
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